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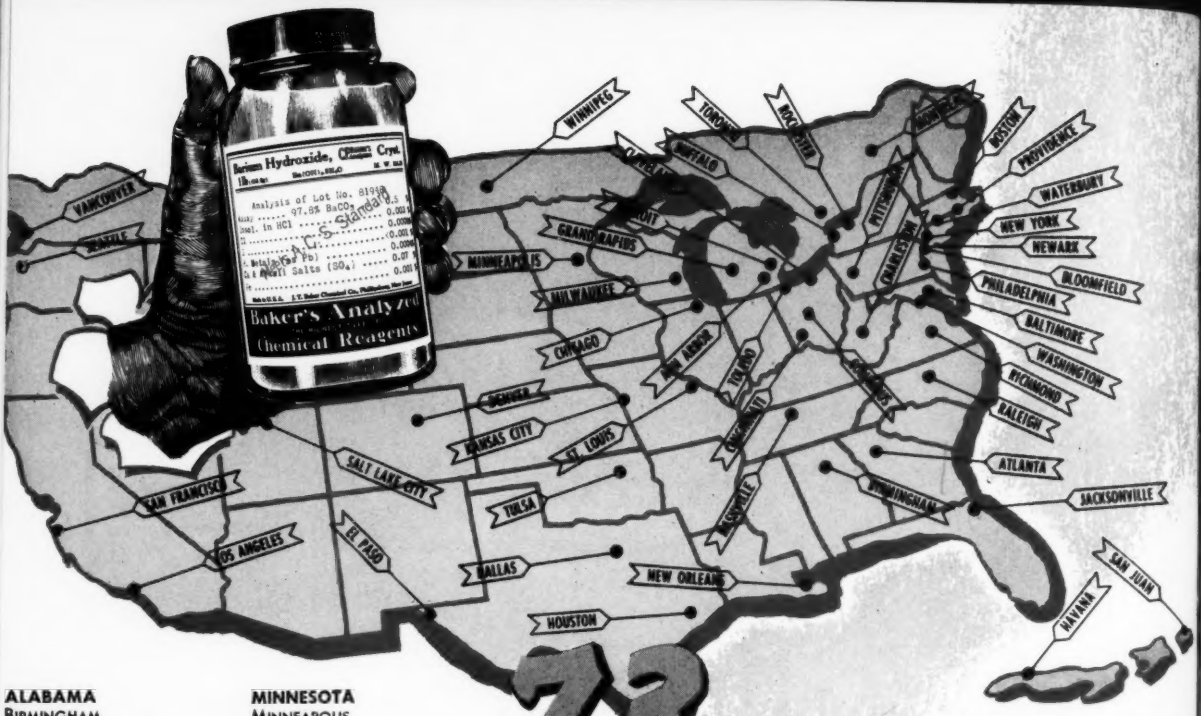

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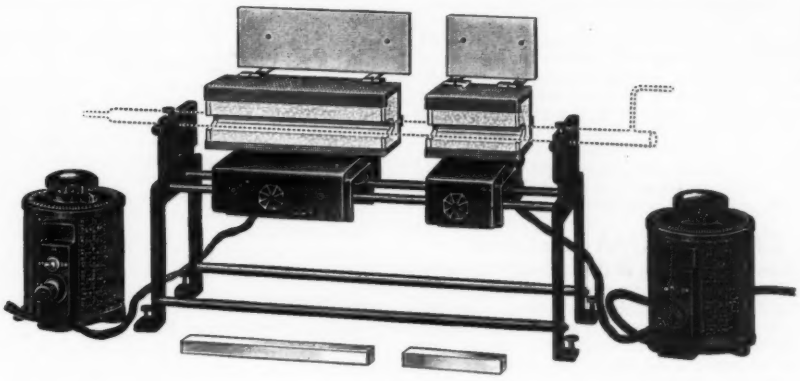

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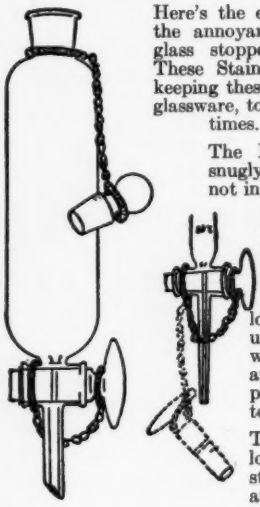

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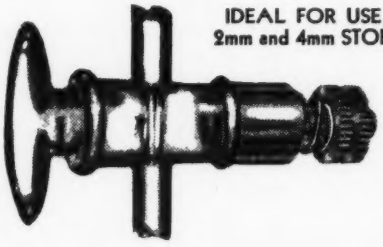

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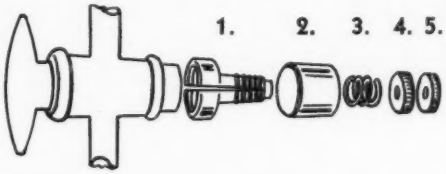

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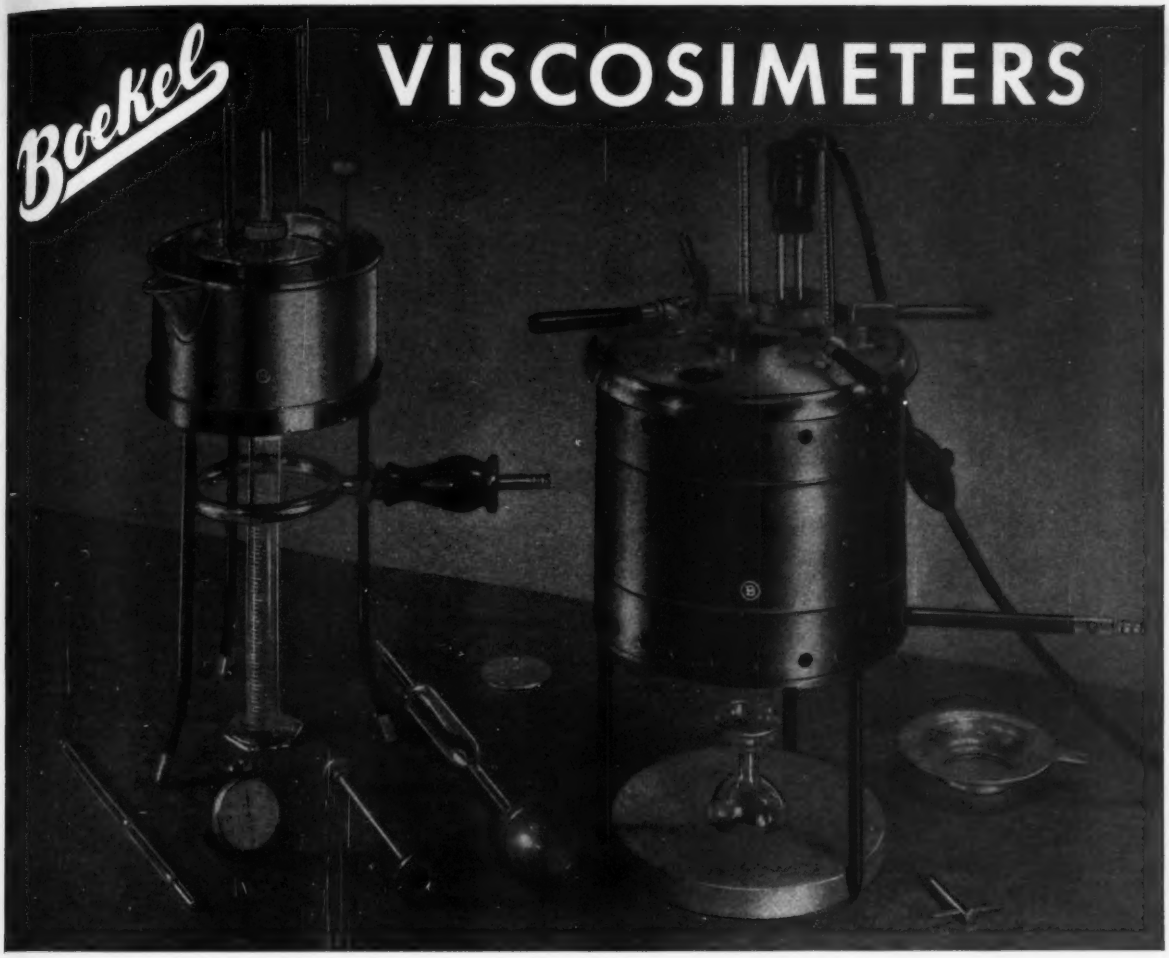

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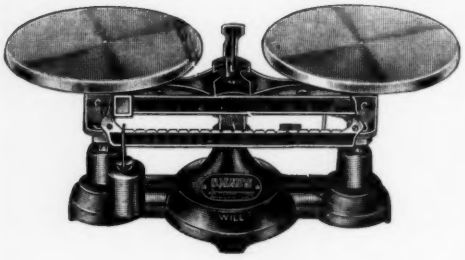

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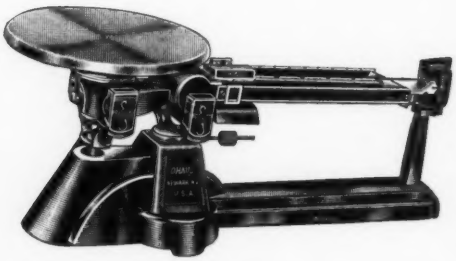

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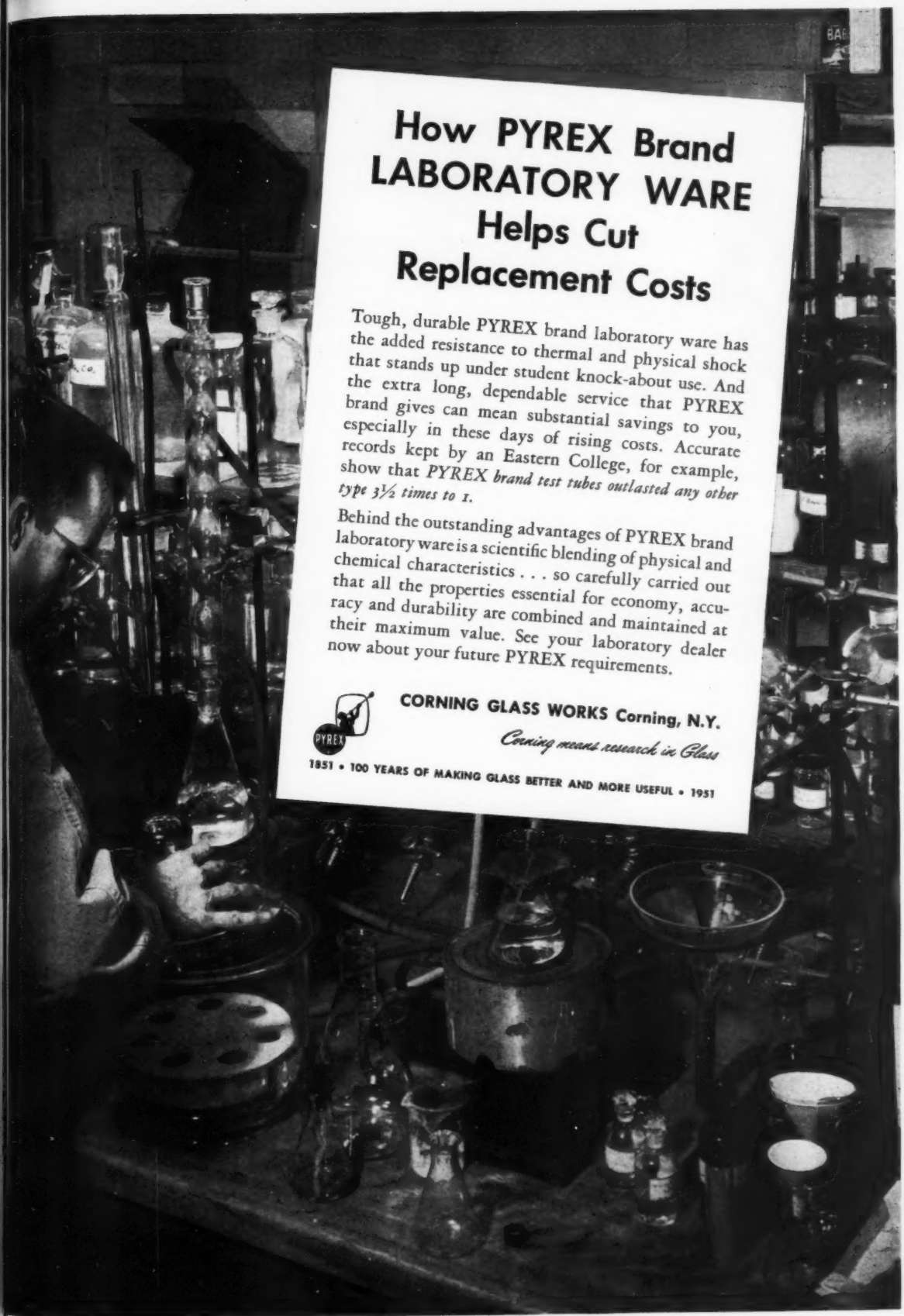
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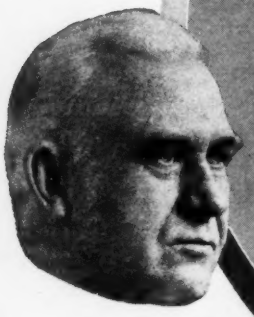

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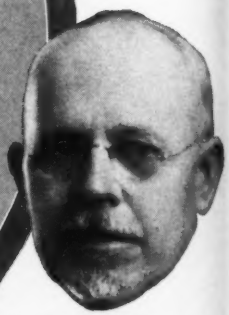

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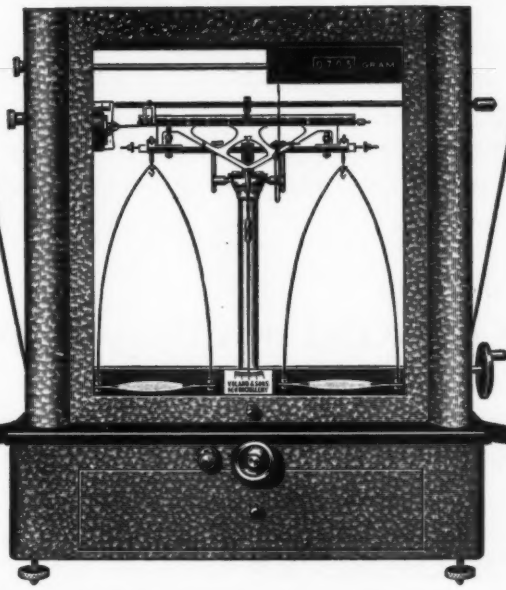

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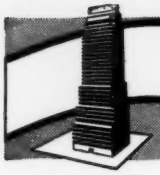

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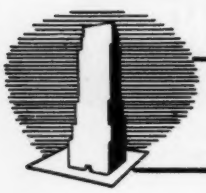

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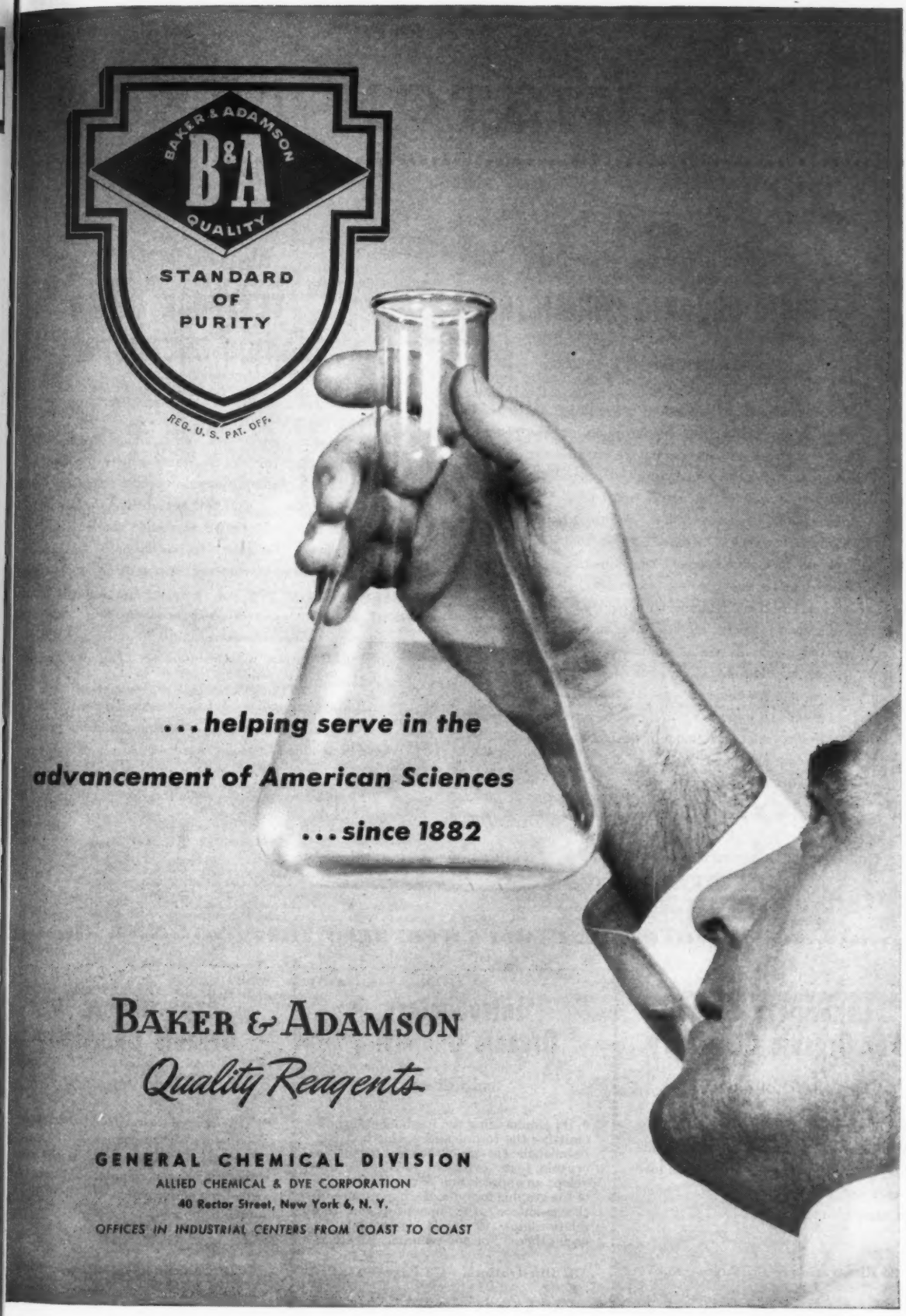
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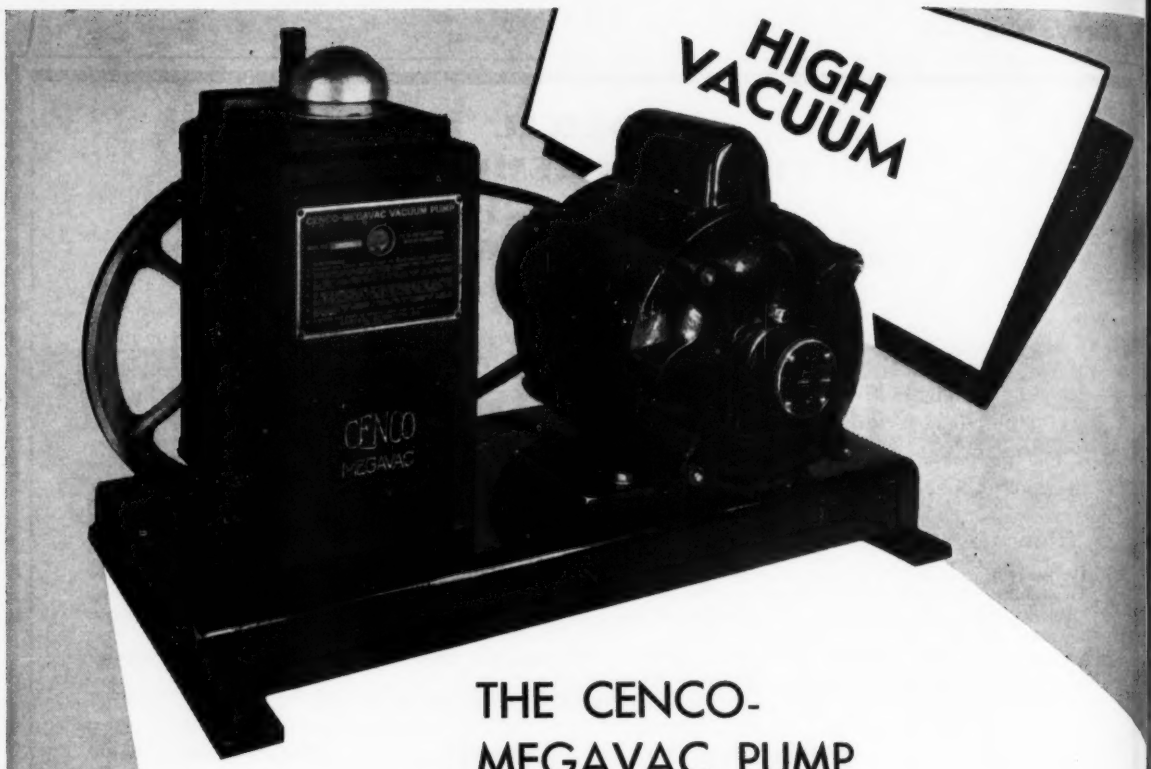

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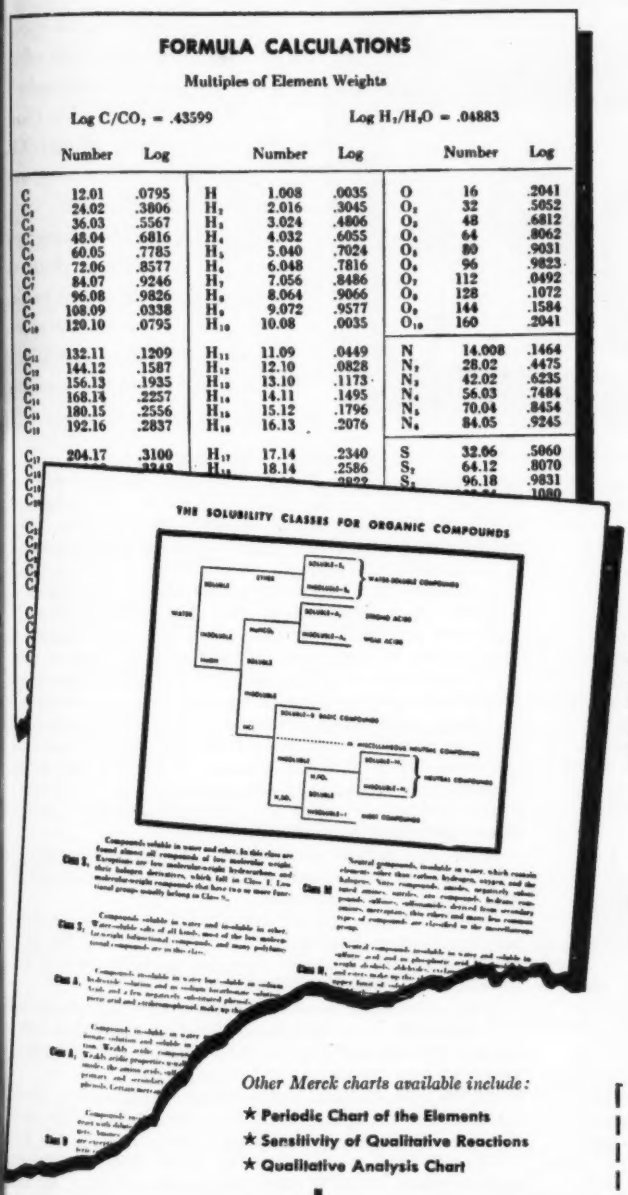

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C_2	24.02	.3806	H_2	2.016	.3045	O_2	32	.5052
C_3	36.03	.5567	H_3	3.024	.4806	O_3	48	.6812
C_4	48.04	.6816	H_4	4.032	.6055	O_4	64	.8062
C_5	60.05	.7785	H_5	5.040	.7024	O_5	80	.9031
C_6	72.06	.8577	H_6	6.048	.7816	O_6	96	.9823
C_7	84.07	.9246	H_7	7.056	.8486	O_7	112	.0492
C_8	96.08	.9826	H_8	8.064	.9066	O_8	128	.1072
C_9	108.09	.0338	H_9	9.072	.9577	O_9	144	.1584
C_{10}	120.10	.0795	H_{10}	10.08	.0035	O_{10}	160	.2041
C_{11}	132.11	.1209	H_{11}	11.09	.0449	N	14.008	.1464
C_{12}	144.12	.1587	H_{12}	12.10	.0828	N_2	28.02	.4475
C_{13}	156.13	.1935	H_{13}	13.10	.1173	N_3	42.02	.6235
C_{14}	168.14	.2257	H_{14}	14.11	.1495	N_4	56.03	.7484
C_{15}	180.15	.2556	H_{15}	15.12	.1796	N_5	70.04	.8454
C_{16}	192.16	.2837	H_{16}	16.13	.2076	N_6	84.05	.9245
C_{17}	204.17	.3100	H_{17}	17.14	.2340	S	32.06	.5060
C_{18}			H_{18}	18.14	.2586	S_2	64.12	.8070
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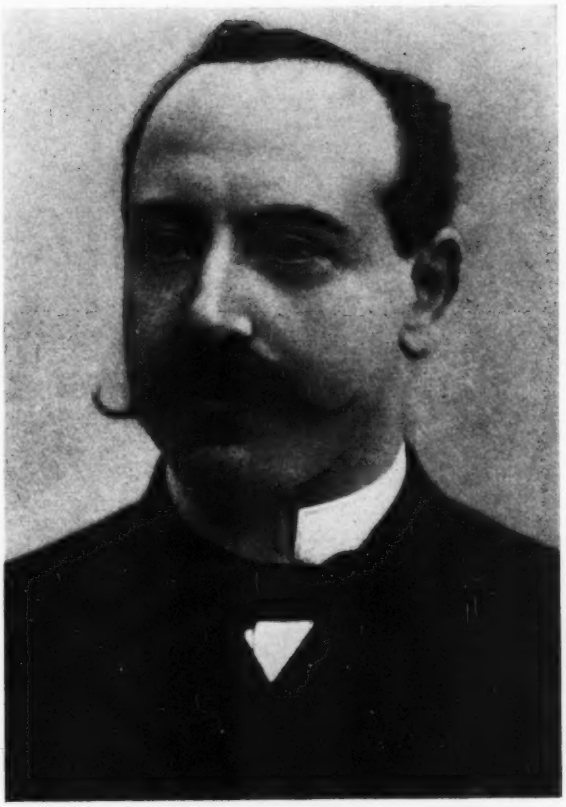

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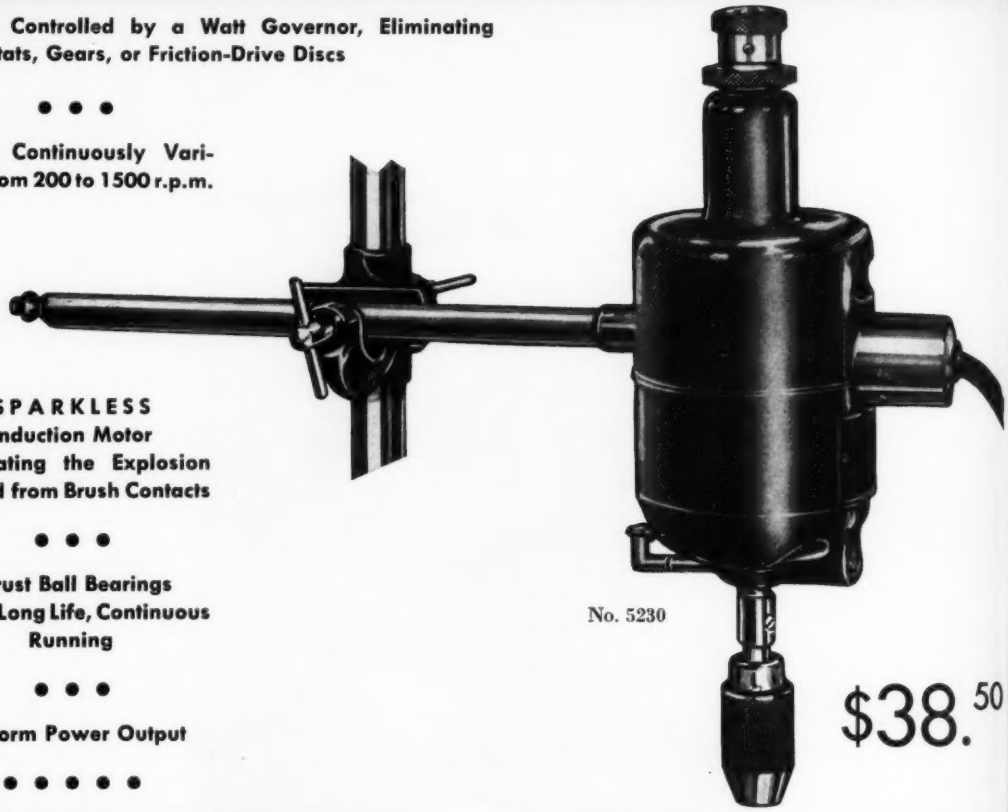

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Editor's Outlook

Of all the things that should be international in outlook and connections education certainly comes to mind as one of the first. Of course, there are inevitably geographical and national differences. Some of these have been brought to the fore by Professor Perry Miller,[1] who thinks that European university education is "fossilized" when judged by American standards.

His experience as a visiting lecturer in Continental universities has shown him that: "The serious (European) student, after a high school that consists of intensive drill in memorization and very little else, enters the university at about 18 . . . is confined to a single 'faculty,' and never, intellectually speaking, gets outside it. Then and there he is committed for life to theology, law, or medicine." The university does not seem to be concerned with his learning about any other field. "It is a professional training ground, and it imparts standard and formal disciplines. In the university, the professor tells the student, and on examinations the student repeats what the professor has told him."

The last of the preceding sounds like one of the familiar complaints at home, but let that be neither here nor there, for the moment. Maybe the colors on the world educational map are really as different as Professor Miller thinks they are, although it is possible that he would have obtained the same impressions had he done his visiting-lecturing at any one of many places in this country sufficiently removed from his own classroom at Harvard.

Nevertheless, it is worth while to consider the contrast in educational outlook which this implies. The contrast is between the "classical" and the "functional," and we shall quickly see that the cleavage is not on the same line as that between the "general" and the "professional."

One philosophy assumes that there has accumulated from the past a discipline of information, skills, and understanding into which a neophyte may be initiated and which he may eventually master. When he has done so he is "educated" and deserves the mark of distinction which announces the fact. The contrasting educational process attempts to develop the skills and promote the understandings which will fit the individual into the environment in which he lives and make him a smoothly working part of the social machinery.

There is something reminiscent here of the conflict between religious scholasticism and science, between a divinely supported doctrine which brooks no change or challenge and a conception of truth which is adaptable to the existing state of knowledge, between the static and the dynamic.

Professional education does not neatly fall into either of these two categories. It can be as fossilized as Professor Miller seems to consider it, by implication. It is inevitably functional, perhaps, but whether in the narrow or broad sense of the term is another question. It is hard to see that an education based entirely on perusal of the Great Books can be functional, no matter how interesting and inspiring it may be.

Educational discussions are so often contradictory. He who starts out to prove that the classical education is the only broadening or liberalizing one sometimes finds that he has only shown its narrowing and confining character. He who collects data to show that professionally educated men are narrow and illiterate sometimes (but not always) finds that they are more broadly and generally informed than the products of the liberal-arts colleges. He who argues that American education is narrow and that Europeans, in contrast, are better fitted by a traditional, classical training to understand world problems and needs may be forced to conclude—as did Professor Miller—that it is European education that is fossilized.

[1] "What drove me crazy in Europe," *Atlantic Monthly*, March, 1951, p. 41. Also quoted in *Time*, March 19, 1951, p. 81.

ROBERT BOYLE AND HIS BACKGROUND

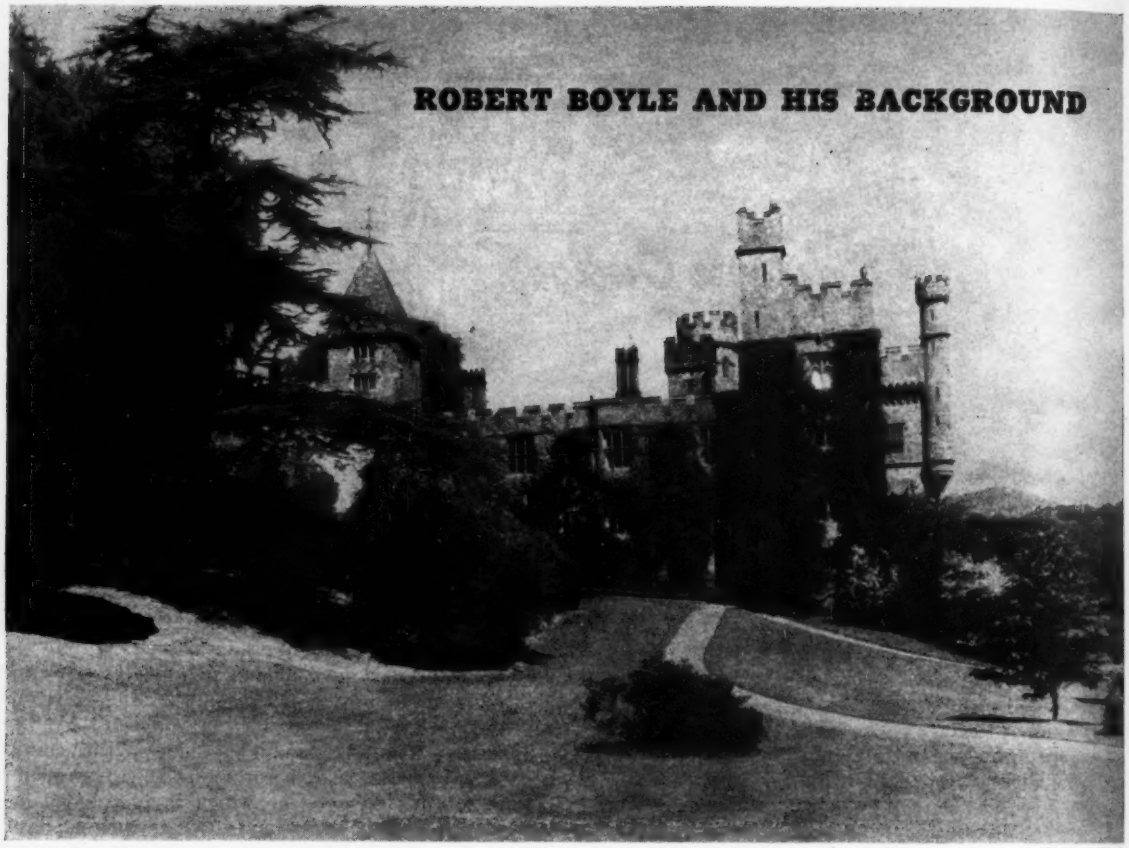

Photo I. T. A.

Lismore Castle, County Waterford, Where Robert Boyle Was Born

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In the Elizabethan age, that produced such men as Walter Ralegh,[1] explorer and soldier, Edmund Spenser, poet, and Isaac Newton, scientist, lived Robert Boyle, the man styled "Father of Modern Chemistry." It was an age of intellectual awakening, when men turned from their voyages of conquest and colonization to the arts and the sciences, and sought clear-cut workable explanations for the workings of nature to replace the often muddled and inadequate theories of medieval times.

Boyle's career was in keeping with the spirit of the age. His father, Richard Boyle, is remembered as the "Great Earl of Cork." Yet he had begun as a poor but ambitious law student at Cambridge. His money ran out and he had to leave college. He decided to go to Ireland and seek his fortune there in the wake of the English soldiers.

[1] Preferred by some historians to the more common spelling, "Raleigh."

Richard Boyle arrived in Ireland on Midsummer Eve, 1588. "All my wealth," he said afterwards, "was then twenty-seven pounds, three shillings in money, and two tokens," which his mother had given him, "...a pair of black velvet breeches...two cloaks...with my rapier and dagger."[2]

In four years, due partly to a good marriage—to Catherine Fenton, only daughter of Sir Jeffrey Fenton, Irish Secretary of State—and his own prudence and careful management, and most important, due to the influence of certain friends in Court, he had risen to an impressive position. His title was "Sir Richard Boyle, Knight, Lord Boyle, Baron of Youghall,[3] Lord Dungar-

[2] Masson, Flora, "Robert Boyle," 1914, p. 5.

[3] Youghall (now spelled Youghal) is still a celebrated seashore town in Ireland, for, according to tradition, Walter Ralegh planted the first potatoes in Europe at his home there. Here, too, the story has it that a servant saw him smoking a pipe of tobacco for the first time, and thinking that he was on fire, promptly doused him with a pail of water.

van, Earl of Cork, Lord High Treasurer of Ireland.[4]

There was nothing honorary about these high-sounding titles, for Boyle had ample wealth and estates to support them, estates planted in the wake of English troops who first cleared out the native Irish inhabitants. Such favorable bargains did the elder Boyle make in his estate deals that he was able to buy additional properties in England. At the time of Robert Boyle's birth his father's means amounted to "two hundred and fifty pounds a day,[5] exclusive of houses and parks." In addition, he was reputed to be the largest land-owner in the British Empire.

It was into this luxury, in the midst of the poverty and want of the dispossessed Irish owners who lived on the fringes of the great estates, that Robert Boyle was born, at Lismore Castle, county Waterford, on January 25, 1627,[6] being the seventh son and the fourteenth child of the family.

Not far away, across the wide river Blackwater, Walter Ralegh had penned sonnets in praise of Queen Elizabeth as he rested between voyages, and Edmund Spenser had worked on his epic poem, "The Faery Queene." On the great estates life went on in leisured cultured ease in that era, while the dispossessed Irish scraped a frugal living in the hills and woods and plotted rebellion against the planters.

Many facts of Robert Boyle's early life are recorded in a strange autobiography which he published later.[7] Here he speaks of himself under an assumed name and in the third person.

Boyle was of a delicate and sickly nature from his childhood. His father, he tells us, "had a perfect aversion" for those parents "who used to breed their children so nicely and tenderly, that a hot sun, or a good shower of rain, as much endangers them as if they were made of butter, or of sugar." As soon, then, as he "was able, without danger, to support the incommodities of a remove," he was sent to an Irish country nurse and brought up on simple fare and plain ways. He was "nursed Irish fashion in a pendulous satchell instead of a cradle, with a slit for the child to look out of." The first words he learned from his foster-mother were in the Gaelic tongue.

Boyle himself believed that his early upbringing hardened and toughened him for later life. This was not the view of some of his biographers, who blamed his frequent bouts of illness in later years on his unusual upbringing.[8] He saw very little of his mother, for she died shortly after he came back from his foster-mother. His mother's death was unfortunate for him in many ways. Despite his father's vaunted ideas on the rugged handling of children he greatly pampered Robert in his boyhood, and allowed him too much of his own way. His studies and teachers were often changed, and he received no formal elementary education, but dabbled in a desoultory sort of way in any subject that took his fancy for the moment.

Though he showed early that he was a versatile and precocious youth, he showed few signs of deep or sustained interest in any branch of study. He later confessed that as a boy he was afflicted with a "roving wildness of...wandering thoughts."[9] This he sought to correct by a study of mathematics. He proved to be a competent linguist from an early age, and was reputed to be fluent in both French and Latin at the age of eight.

Boyle's boyhood records a number of amazing escapes from injury at various times. When still only a child, he was traveling by coach to Dublin. The carriage had to cross a wide stream in flood from heavy rains. Young Robert was left in the coach with a foot-boy, when "a gentleman of his father's, very well horsed, accidentally espying him, in spite of some others and his own unwillingness and resistance, carried him in arms over the rapid water, which proved so much beyond expectation both swift and deep that horses with their riders were violently hurried down the stream, which easily overturned the unloaded coach, the horses (after by long struggling they had broken their harness) with much ado saving themselves by swimming."[10]

When Robert went to Eton with his brother Frank at the early age of nine the English boys did not like the "uncouth Irish manners" of the new arrivals. Robert had a slight stammer, which did not help matters. He generally avoided the other boys and was usually to be found engrossed in a book in a quiet corner during recreation period.

At Eton, Robert had another of his almost disastrous accidents. He was not as good a horseman as his brother, and once when they were out riding together Robert was unseated, and the horse stepped so near to his throat that it tore a hole in his collar, "which he long after preserved as a remembrance." Another time, an apothecary's servant gave him a strong emetic in mistake for a cooling draught, and for a time his life was in danger. He said himself that this accident made him "long after apprehend more from the physicians than the disease,"[11] and was probably the reason why in later life he devoted a considerable amount of time to the study of chemistry in relation to the human body. Besides, to the end of his life, Boyle would never allow a doctor to attend him, but constantly dosed himself with medicines of his own invention.

Yet another accident at Eton was the collapse one night of the wall of the bedroom where the Boyle brothers slept. They had gone to their room early, and

[4] HENDERSON, T. F., "Dictionary of National Biography," Oxford University Press, London, 1908, Vol. 2, p. 1021.

[5] This is equivalent to about a quarter of a million dollars a year, without taking into account the fact that the value of money was far higher then than now.

[6] TILDEN, "Famous Chemists," London, 1921, p. 1.

[7] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 1st ed., 1744, Vol. 1.

[8] CLERK, AGNES M., "Dictionary of National Biography," Oxford University Press, London, 1908, Vol. 2, p. 1026.

[9] MORE, LOUIS T., "Life & Works of the Honourable Robert Boyle," Oxford University Press, New York, 1944, p. 29.

[10] *Ibid.*, p. 23.

[11] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 2nd ed., 1772, Vol. 1, p. 16.

Robert was already in bed while Frank sat by the fireplace talking to some other boys. Suddenly and without warning the wall of the room fell inwards, carrying the ceiling with it, as well as a bed, chairs, books, and furniture from the room above. A bigger boy rescued Frank from the dust and debris, the chair in which he had been sitting smashed to pieces, and the clothes torn from his back. Robert, the future chemist, in his bed, remembered to wrap his head in the sheet, so that, as he said, it might serve "as a strainer, through which none but the purer air could find a passage."[12]

After three years at Eton, the Boyle brothers engaged a French tutor and traveled for five years on the European continent, visiting France, Switzerland, and Italy. Robert's mastery of French was said to be so good that he was often mistaken for a native in his travels there. For a season, the brothers stayed in Geneva, where Robert, then fourteen years old, tells us that he was "enamoured of those delightful studies, arithmetic, geometry with its subordinates, the doctrine of the sphere, that of the globe, and fortification."[13]

They traveled on to Italy and were in Florence the year that Galileo died. Robert learned Italian and read Galileo's works with interest at that period. They proceeded to Rome where they viewed the classical monuments, and embarked for Marseilles. At that point they received bad news from home. It was the year 1642, and rebellion had broken out in many parts of Ireland. The "Great Earl" found himself hard pressed, not only with keeping the rebels in hand but with the great strain which the payment of large mercenary forces imposed on his revenues. A few years before, the Earl had allowed an elder son, Richard, a thousand pounds a year to travel in Europe. Now, it was only with the greatest difficulty that he was able to collect two hundred and fifty pounds to send to Frank and Robert to pay their way home.

But worse was to follow, for their father's money never reached them. Enough money was scraped together to send Frank home directly, and then Robert and his tutor traveled back almost penniless to Geneva, and there managed to collect enough money for the journey home by pawning the jewels they wore.

By the time they got back, the Earl had died and Irish affairs were still in confusion. Robert found that as his share of the estate he had been given one of his father's English properties in Devon. Here he went to live, and here he began the studies which were eventually to lead to his brilliant scientific work. Throughout his life he never married, and he had little if any interest in the many attempts which were made by well-meaning friends to find a wife for the very eligible and prosperous young man who dabbled in scientific experiments.

At first he worked alone, but later he came into contact with others trying to straighten out the tangles of medieval thought and place science on a practical basis.

For a time he toyed with the idea of returning to Ireland, making it his home, and carrying on his work there. He paid a brief visit to his old home but found the country broken and improverished by war. That Boyle, immersed in his scientific work, was far removed from the realities of the Irish scene was borne out by his comment at the time that Ireland was "a barbarous country where chemical spirits were misunderstood and chemical instruments. . .unprocurable."[14] He gave up his idea of living in Ireland and returned to England, where he spent the remainder of his life.

However, his short stay in Ireland had not been without some profit. He found a new friend in Dr. Petty, who taught him anatomy and became one of his greatest admirers. Petty was an extraordinary and versatile man, who spent an adventurous boyhood in France, studied anatomy, and taught both music and anatomy in England. He then became physician to the English army in Ireland, and like the "Great Earl" acquired huge estates in county Kerry which he developed to a sizeable fortune. Returning to London, he became a leading physician and a founder of the Royal Society.[15]

Largely on the advice of Petty, Boyle decided to devote his talents entirely to scientific work and decided to settle either in London or in Oxford. At first he favored London, where his sister, Lady Ranelagh, lived, and where he could meet with his friends who styled themselves the "Invisible College." These were a small circle of scientific inquirers who met weekly in coffee houses with the declared purpose "to discourse and consider of philosophical inquiries and such as related thereunto (precluding matters of theology and State affairs)."[16]

But London was in a turbulent state in that Civil War period, and besides many of the members of the "College" had moved to Oxford where they were now attached to the University. Boyle was urged to join them, and he finally went to live in Oxford in 1654.

There he passed fourteen of the most fruitful years of his life. He at once entered prominently into the life of the University and became an intimate friend of many of its leading scholars. He established laboratories, hired many assistants to carry out his experiments, spent much money, and entertained lavishly, keeping up two houses, one four miles out in the country.

It has been lightly assumed that Boyle at once took over the position of an acknowledged master of the sciences on his arrival in Oxford. The fact was that, because of his earlier scattered education, he served almost six years as a sort of apprentice to the foremost scholars of the day before attaining scientific prominence.[17] When he went to Oxford Boyle was accompanied by Peter Sthael,[18] a noted chemist and Rosicrucian of

[12] FARRINGTON, A., "Life of Boyle," Cork, Ireland, 1917.

[13] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 1st ed., 1744.

[14] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 2nd ed., 1772, Vol. VI, p. 54.

[15] MORE, LOUIS T., "Life & Works of the Honourable Robert Boyle," Oxford University Press, New York, 1944, p. 76.

[16] BIRCH, THOMAS, "History of the Royal Society," 1755.

[17] MORE, LOUIS T., "Life & Works of the Honourable Robert Boyle," Oxford University Press, New York, 1944, p. 91.

[18] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 2nd ed., 1772, Vol. VI, p. 122.

Strasbourg, who taught him geometry, the Cartesian philosophy, and chemistry. Little of Boyle's scientific work was published until the Restoration in 1660, by which time his apprenticeship might be said to have ended. A notable exception, however, was his work, "On the Spring and Weight of the Air," which appeared in 1657. However, as will be pointed out later, much of the credit for this notable work belongs to Boyle's able assistant, Robert Hooke[19] rather than to Boyle himself.

With the Restoration, meetings of the "Invisible College" were revived, and late in 1660 King Charles II constituted the group under charter as the Royal Society, with Boyle as one of the founder members. Charles II may not be remembered in English history for many notable achievements, but his founding of the Royal Society was a genuine landmark in the progress of science. It was said that the King had little real interest in science and was more amused than instructed by the brilliant work of its early members. Yet without doubt, the Society performed a signal service to modern science in those early years of its existence.

The bulk of Boyle's work was published in those first years of the restored monarchy. At Oxford, between 1660 and 1666, he published ten large volumes, and twenty papers in the *Transactions of the Royal Society;* then followed a period of silence for five years, except for six papers in the *Transactions.*

It is something of a mystery how Boyle published such a great quantity of work in such a time. More[20] puts forward the possible explanation that: "he was rather the director of a laboratory than an individual experimentalist. As such, he employed numerous assistants and mechanics, who made the observations and did the detailed work on the problems he set them. And he must have had a staff of secretaries, who managed his great correspondence, collected the mass of data and recipes he published, read to him, and wrote to his dictation."

Among the many laboratory workers who assisted him in part of his work at a later date was the remarkable Wilhelm Homberg, born in Java in 1652, and educated in Europe, and later the first to prepare (in 1702) boric acid.[21]

Boyle's gathering fame in the world of science, coupled with his wealth and social position, brought many crackpots and inventors to him with the request that he bring their schemes to the notice of the government. Most of the schemes were far-fetched and impossible, but one of them at least, which Boyle was instrumental in introducing to the British Navy, was of real value. This was a method of preparing fresh from salt water.

[19] For fuller information on the life and times of Robert Hooke, see "The Diary of Robert Hooke," Henry W. Robinson, ed., Taylor & Francis, London, England, **1935.** As a foreword, the "Diary" carries a 16-page sketch of Hooke's life and work.

[20] More, Louis T., "Life & Works of the Honourable Robert Boyle," Oxford University Press, New York, **1944,** p. 107.

[21] Weeks, Mary E., "Discovery of the Elements," 5th ed., J. Chem. Educ., Easton, Pa., **1945,** p. 334.

Robert Boyle

Boyle was a religious man, and published a number of pious sermons and tracts under his own name. These would probably have long since been forgotten but for Dean Jonathan Swift's merciless parody of them in his "Pious Meditation on a Broomstick in the Style of the Hon. Mr. Boyle."[22] A recent writer has made the claim that it was one of Boyle's religious tracts, entitled "Reflection Upon the Eating of Oysters," that gave Dean Swift the idea of writing his celebrated "Gulliver's Travels."[23] At his own expense, Boyle had a translation of the Bible into Gaelic prepared and published.

Robert Boyle has often been referred to as Sir Robert Boyle. This is incorrect, for though offered a knighthood, he refused it as well as most other honors, and busied himself with his experiments. However, he seems to have been unable or unwilling to avoid all obligations thrust on him. For instance, in 1664 he accepted membership in the Company of Royal Mines and spent the winter in London. This position involved work which he specially favored. He made many inspection trips, exploring the minerals and soils of the country and their possible uses for both industrial and medicinal purposes. He also made, over a long period, a rich collection of ores and minerals which in his will he left to the Royal Society.[24]

[22] Nichols' Edition of Swift's Works, **1812,** Vol. 1, p. 113.

[23] More, Louis T., "Life & Work of the Honourable Robert Boyle," Oxford University Press, New York, **1944,** pp. 158–9.

[24] *Ibid.,* p. 117.

Boyle suffered through much of his life from increasing weakness of the eyes, and beginning with the year of the Great Plague, 1665, when many suffered from agues and periodic fevers, he was prone to chills and colds. So careful did be become of his health that it was said that he had a closet filled with different cloaks, with a special cloak for each change in temperature. As might be expected from the man who first suggested the melting point and boiling point of water as fixed points on the themometer, he would read his thermometer each morning before leaving home and then select the cloak most suited to the day.[25] While mentioning temperature, it is of interest to note here that Boyle was the first in England to make use of mixtures of salt and snow to reach low temperatures.[26]

Boyle lived mainly in Oxford until 1667, when he moved to London and lived with his sister, Lady Ranelagh, on Pall Mall. In spite of increasing infirmities he continued to publish steadily on all manner of subjects and carried on correspondence with many foreign workers. So tiring was the routine when his house became a rendezvous for increasing numbers of visitors and guests that he was compelled to publish a notice stating that he would be at home to visitors on certain days of the week only.[27]

Boyle's sister died December 23, 1691, and his own death followed a week later, on December 30, 1691. He died peacefully without the pain that he had dreaded. It is said that his end was hastened by his own ill-advised doctoring attempts with medicines of his own invention.

More [28] remarks that "there is little need to add a critical analysis of Boyle's character. He was blessed with such a simple and transparently clear integrity of mind that his contemporaries, intimate friends, and casual acquaintances alike were singularly unanimous in their estimates of him as a man and scholar; and he himself was so expansive and so self-revealing in his published works and letters that there is little difficulty in knowing the whole man."

Reference has already been made to Boyle's first publication in 1657, "On the Spring and Weight of the Air." This and later work which he published on the same lines upset many of the old views on air. "Nature abhors a vacuum," was the cry of the ancients, for they believed that a completely empty space, free of air and all other gases, could not exist.

Toricelli, a pupil of Galileo, had already done much to show that a vacuum was possible. Working with his assistant, Robert Hooke, Boyle devised his air pump which was an adaptation of one invented by Otto von Guericke, the Burgomaster of Magdeburg, in 1634,[29] and which was based directly on information published in a book by the Jesuit Schottus.[30]

Using the pump, Boyle and Hooke determined the weight, elasticity, and the part played by air in combustion. In upsetting so many of the earlier views on air Boyle remarked with truth that "the generality of men are so accustomed to judge of things by their senses that because the air is invisible they ascribe but little to it, and think of it but one remove from nothing."[31]

He also described apparatus and methods for distilling under reduced pressure.[32] Boyle's work on air was of considerable significance in medical history. While Harvey had clearly demonstrated the course and mechanism of the circulation of the blood, he had given no reason as to *why* the blood circulated. The answer to this question was given in part by some of Boyle's experiments on air.[33] Using the air pump, Boyle showed that in a vacuum a mouse or small bird could not live, nor would a candle burn. However, if the supply was renewed in time the bird or animal would recover. Clearly then air was essential for life and for combustion.[34]

Boyle's interest in the effect of pressure on air led him to the discovery of the elastic nature of gases, which he succeeded in establishing for pressures both lesser and greater than atmospheric. The celebrated generalization is known widely as Boyle's Law, but it is still often referred to as Mariotte's Law. It was announced by Boyle in 1662 as a result of extensive and carefully executed experiments by Hooke and himself. Mariotte's work was much later in date and was based on very few experiments.[35]

While the specific experiments in the work on air can be rightly credited to Boyle, much of the success in this work rested on the efforts of Hooke, for the results secured were dependent on Hooke's development of an efficient gas pump and accesory apparatus for the manipulation of gases. Boyle, in his first edition, did not credit Hooke with the creation of the air pump, for it was not usual in those days to mention laboratory assistants specifically. When, however, the publication made a dazzling success, and the air pump was regarded as an eminent invention comparable to that of the telescope, Boyle gave full credit in the second edition to Hooke. But the scientific and social world had already hailed Boyle as the inventor. The original apparatus presented to the Royal Society is exhibited in the Library as Boyle's Pump. Evelyn's "Diary" and other

[25] BOYLE, ROBERT, "Works," ed. by Thomas Birch, 1st ed., 1744, Vol. 1, p. 86. PICTON, "The Story of Chemistry," 1889, p. 127.

[26] BOYLE, ROBERT, "New Experiments Touching Cold," 1665.

[27] MORE, LOUIS T., "Life & Work of the Honourable Robert Boyle," Oxford University Press, New York, 1944, p. 132.

[28] *Ibid.*, p. 133.

[29] GUERICKE, OTTO VON, "Experimenta Nova Magdeburgica de Vacuo Spatio," Amsterdam, 1634.

[30] "Mechanica Hydraulico-Pneumatica," 1659.

[31] BOYLE, ROBERT, "Memoirs for a General History of the Air," Shaw's Abridgment of Boyle's Works, 1725, Vol. 3, p. 61. SIR WILLIAM RAMSAY, "The Gases of the Atmosphere," Macmillan and Co., Ltd., London, 1915, p. 10.

[32] PARTINGTON, J. R., "Short History of Chemistry," London, 1939, p. 69.

[33] GUTHRIE, DOUGLAS, "History of Medicine," London, 1945, p. 186.

[34] STIRLING, W., "Some Aspects of Physiology," London, 1902, p. 39.

[35] MCKIE, DOUGLAS, "Boyle's Law," *Endeavour*, 7, No. 28, (October, 1948).

contemporary writers refer to the frequent and exciting demonstrations of Boyle's Engine, and that opinion still persists.

In the light of Boyle's later work the plan and conduct of the work was more obviously Hooke's, whose taste and genius directed him to mechanical problems, rather than Boyle's, whose interests lay in the chemical composition of bodies. The final and convincing proof that air, like other bodies, had a definite weight was first given in the second edition, to answer the objections of Linus, an English Jesuit and professor of physics at Liege, by a crude determination of Boyle's Law. That same year, 1662, Hooke moved to London as curator of the Royal Society. Boyle, although he afterwards frequently discussed the properties of air, abandoned any further work of a mathematical or quantitative type, while Hooke devoted himself expressly to that kind of work, and in fact included Boyle's Law in his general formula for elasticity.[36]

Boyle believed heat to be a brisk molecular motion and not a material substance, thus antedating in part ideas which only assumed full sway in the last century. Boyle's views in this respect appear on recent evidence to have had their source in the speculations of Hooke in the course of his work at the Royal Society.[37]

Boyle was the first to distinguish clearly between a mixture and a chemical compound. He held the idea that the elements then obtained by chemical workers were not the ultimate constituents of matter. His ideas were put forward in his "Sceptical Chymist" in 1661. He defined the elements in a manner strangely prophetic of more modern work as being compounds of one universal matter. In his view the entire visible part of the universe could be ascribed to the various modes of movement and grouping of the universal matter. In his book, Boyle put forward for the first time the idea that chemical combination takes place between small particles of each element, particles which he calls "corpuscles,"[38] and that all elements are fundamentally composed of such tiny particles.

It has been held that Boyle discovered phosphorus independently of Henry Brand, the Hamburg alchemist who first prepared the element in 1669.[39] Actually, the facts on the matter are not entirely clear. Brand was a trusting man who showed his phosphorus, or "cold fire" to a friend, Dr. Johann Daniel Krafft of Dresden, who suggested that the secret preparation might be sold at a high price to some royal personage. Krafft exhibited the "cold fire" to the Great Elector of Brandenburg, at the court of Hanover, and at the Royal Society in London before Boyle and other members in 1677. Boyle shortly afterwards prepared phosphorus by a slightly different method and studied its properties more exhaustively than did any other chemist of the seventeenth century.[40]

Boyle himself maintained that his preparation of phosphorus was carried out without any previous knowledge of the German process. Boyle was a man of high integrity and one cannot doubt the truth of his statement. However, Krafft asserted quite definitely that he had communicated the Brand process directly to Boyle.[41] Subsequently, Boyle's assistant, Godfrey Hanckwitz, made phosphorus on quite a large scale and exported it to Europe in commercial quantities.

The field over which Boyle's work ranged was a large one. He prepared and described hydrogen gas,[42] and prepared nitrogen, although he failed to recognize the independent nature of the latter element. He was the first to use vegetable coloring matter in tests for acidity and alkalinity.[43] He introduced the use of chemical reagents, including silver nitrate and barium chloride, and first used the term "analysis." In addition, he illustrated the uniformity of potassium salts in different ways. Generally, his analytical experiments cast serious doubts on earlier alchemical theories. Yet Boyle was true to his time for, like his contemporaries, he clung to a belief that transmutation of individual elements was possible.

Partington[44] says of Boyle that "he has been called the father of modern chemistry for three reasons: (1) he realised that chemistry was worthy of study for its own sake and not merely as an aid to medicine or as alchemy—although he believed in the possibility of the latter; (2) he introduced a rigorous experimental method into chemistry; (3) he gave a clear definition of an element, and showed by experiment that the four elements of Aristotle and the three principles of the alchemists (mercury, sulphur, and salt) did not deserve to be called elements or principles at all, since none of them could be extracted from bodies, e.g, metals."

Boyle's name may not be associated with many outstanding chemical discoveries, and there are those who claim that much of his work was superficial. Yet the place of Robert Boyle, son of an Elizabethan adventurer in Ireland, is an assured one in chemical history. In demolishing the half-truths and false premises of the alchemists, he was far in advance of his time, and the multitude and clarity of his experiments offered numerous starting points for original research for those who followed in his footsteps.

[36] More, Louis T., "Life & Works of the Honourable Robert Boyle," Oxford University Press, New York, 1944, p. 95.

[37] Patterson, Louise D., "Robert Hooke and the Conservation of Energy," *Isis*, 38, No. 113, pp. 151–6 (February, 1948).

[38] Boyle, Robert, "The Sceptical Chymist," Fulton ed. 34, Oxford, 1680, p. 396.

[39] Anon., "Merck Report," Rahway, New Jersey, 1948, p. 19.

[40] Weeks, Mary E., "Discovery of the Elements," 5th Ed., J. Chem. Educ., Easton, Pa., 1945, p. 43; Hermann Peters, "Geschichte des Phosphors nach Leibniz und dessen Briefwechsel," *Chem.-Ztg.*, 26, p. 1190 (Dec. 13, 1902).

[41] Kopp, H., "Geschichte der Chemie," F. Vieweg und Sohn, Braunschweig, 1847, Part 3, p. 329.

[42] Millar, A., "The Works of the Hon. Robert Boyle," London, 1794, Vol. 3, p. 255; *ibid.*, Vol. 5, p. 111.

[43] Boyle, Robert, "Reflections upon the Hypothesis of Alcali and Acidum," 1675.

[44] Partington, J. R., "Short History of Chemistry," London, 1939, p. 67.

A NEW MICROPROJECTOR

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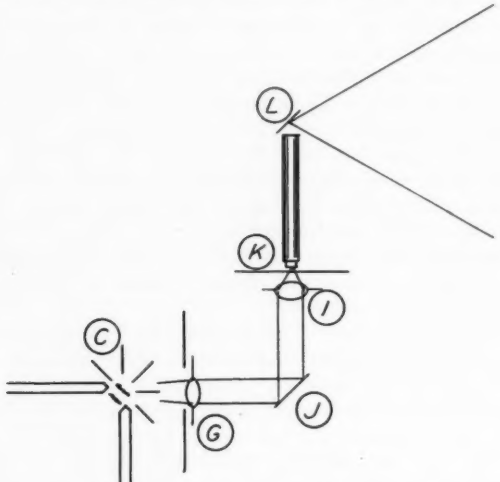
A NEED has arisen for a simple microprojection apparatus answering the following requirements: project an image of four square feet, bright enough to be seen



Essential Components of a Microprojection System

by an audience of three hundred persons; be portable and easy to assemble and dismantle; and operate on 110 volts a. c. The system described below was developed to answer this need.

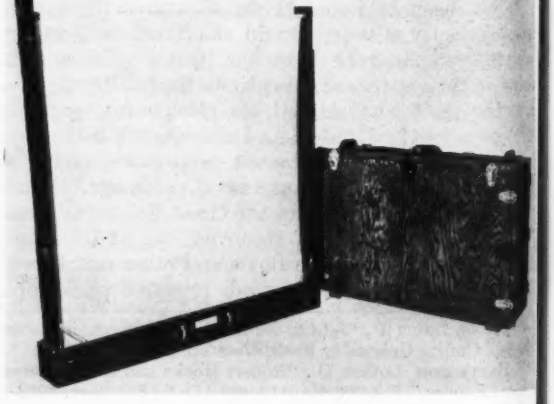
The basic optical requirements for a microprojection system are shown above. The condenser (*G*) gathers the light from the light source (*C*). The mirror (*J*) reflects the light to condenser (*I*) which focuses the beam on the microscope stage (*K*). An enlarged image of the specimen under observation is formed by the microscope and reflected by mirror or prism (*L*) to the screen.

A number of microprojectors are commercially available but have the disadvantages of high cost, weak light source, lack of portability, etc.[1] The system described can be built for about $150, not including the microscope. The authors have used a petrographic microscope with the projector to utilize polarized light; however, biological or other types of microscopes can be used.

The principal problem in obtaining adequate projection has always been the light source. A carbon arc on 110 volts d. c. is highly satisfactory, but unless magnetically controlled, requires constant attention. Further, few lecture halls even in chemistry and physics laboratories have 110 volts d. c., and the a.-c. arc, especially with low amperage current, is noisy, hard to start, and much less intense a source than the d.-c. arc.

A number of other light sources were considered, among them the zirconium arc, high pressure mercury arc, tungsten arc, and the tungsten filament. All of those listed except the latter required heavy auxiliary equipment. Since home movie projectors have essentially the same problem and solve it by using tungsten filament lamps, a system of this type was chosen. A 750- or 1000-watt biplane filament projection lamp, the same type used in 16-mm. film projectors, was used. A housing was built using a prefabricated metal box (available through any radio supply house) and incorporating a fan for cooling the bulb, a lamp socket, switch, and reflector.

A Bausch & Lomb Model B microprojector was disassembled to provide a support for the optical system, heat absorbing cell, and microscope. The assembly is shown on the opposite page. The blower (*A*) handles about 50 c.f.m. of air to cool the light source (*C*). The chimney (*B*) directs the air stream over the bulb. The metal reflector (*D*) is mounted behind the bulb to direct as much light as possible forward. The hot air is ejected

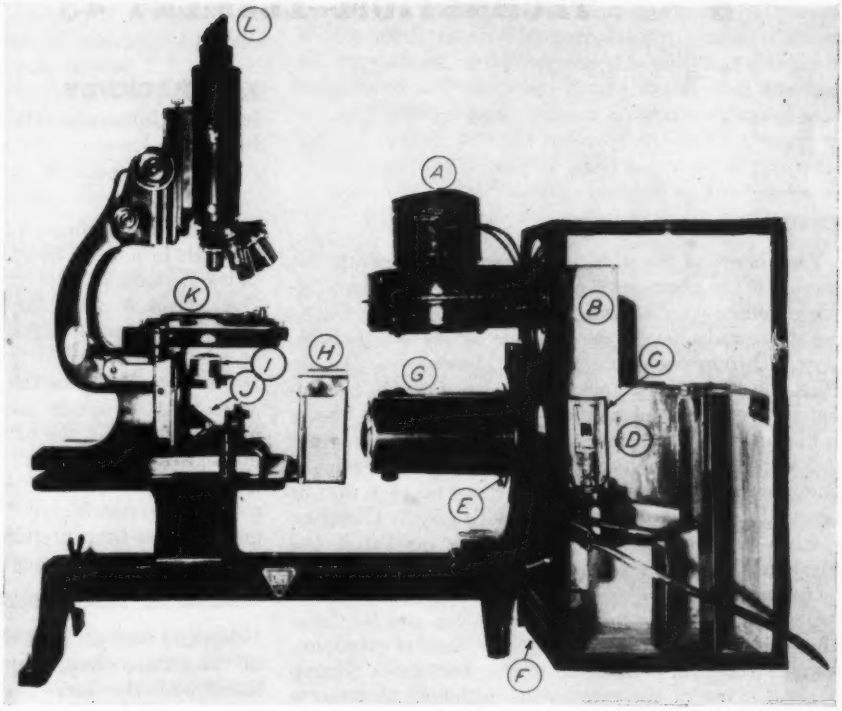


Screen and Case

(Left) The screen hangs from a dowel rod. The screen may be rolled up and placed in the base and the supports folded down to provide a carrying case. (Right) The "suitcase" houses the projector ready for traveling.

[1] A new projection microscope has recently become available, namely the Promi instrument sold through W. H. Kessel and Co., Chicago. It should be investigated by anyone interested in acquiring a microprojector.

through the openings at (*E*) and (*F*). The light emerges through the opening (*E*) and passes through the condensing system (*G*) consisting of two double convex lenses of focal length about ten inches. A water cell (*H*) is interposed to remove most of the infrared light. The light is then reflected by the microscope mirror (*J*) through the condenser lens (*I*), a simple convex lens at least one inch in diameter and with a focal length of about two inches. (This large lens in place of the usual microscope substage condenser is one of the greatest single improvements embodied in this projector.) The image leaving the microscope eyepiece is reflected by the prism (*L*) to the screen.



The blower and bulb are wired in parallel so that the bulb cannot be on when the blower is not operating. With this precaution the life of the 750-watt lamp is rated at 25 hours; of the 1000-watt lamp at 10 hours.

The carrying case has been designed to serve not only to carry the projector but also to open on three sides to permit access for projection without the necessity of removing the projector from the case. This has the further advantage of shielding stray light from the screen and room. Two wooden dowel rods are provided on which black curtains are hung to completely enclose the apparatus except for the top. In some cases it is desirable to cover a part of the top also with additional black curtains. After use the case is closed to form a "suitcase" as shown in the figure.

Projection is carried out from behind a translucent screen. This enables simultaneous and completely unhindered visibility of the screen both by the lecturer and the audience. The screen (see figure), a 36-inch square of tracing cloth, is hung from a wooden $^3/_8$-inch dowel rod and has a $^1/_4$-inch straight aluminum rod in the hem at the bottom. The screen is hung from supports formed by two uprights hinged to the base. The base also acts as a carrying case for the rolled up screen. With the screen in the case, the uprights are folded down and clamped into place. When folded ready for carrying, the case is only $3 \times 3 \times 38$ inches.

All accessories are tucked into unused corners of the projector case when the projector is packed for carrying. The body tube of the microscope, for example, must be removed, wrapped in cloth, and packed away in the bottom of the case, since there is insufficient headroom to permit closing the case with the entire microscope in place. The complete unit ready to travel weighs about 75 pounds, which aids in the stability and absence of vibration when projecting. No great difficulty has been encountered due to its weight on a number of long trips by train or by airplane.

ACKNOWLEDGMENT

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TECHNETIUM—ELEMENT 43

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HISTORICAL INTRODUCTION

The Puzzle of the Missing Elements. At about the middle of the nineteenth century, approximately fifty-five elements were known, most of them discovered by the then newly developed methods of analytical chemistry. During the same period, Mendeleev (*31*) devised the Periodic System, by means of which he predicted several new elements needed to fill up the blanks in his table. Only a few of these, notably germanium and scandium, were discovered by analytical methods. The missing elements were believed to be very rare or unusually difficult to isolate, or both (*53*). Therefore a more powerful analytical tool was needed if the puzzle of the missing elements was to be solved.

Optical Spectroscopy. Such a tool was provided in the optical spectroscopic methods of Bunsen and Kirchoff. These methods made possible the discovery of rubidium, cesium, thallium, indium, all of the inert gases (Group O), and many of the rare earths, although there were still many blank spaces.

Natural Radioactivity. At about the beginning of the twentieth century, a new and still more powerful method made possible the discovery of radium, polonium, and other new elements. This new analytical tool, radioactivity, is the most sensitive technique now known, being capable of detecting radioactive isotopes in concentrations much smaller than would be possible even by spectroscopic methods (*53*). This method is applicable only to unstable atoms in the process of decomposition, and unstable isotopes of mean life much less than the order of 10^9 years are not considered capable of existing in natural minerals. Its range of application is therefore limited.

X-ray Spectroscopy. In 1912, Moseley (*32*), by use of a new analytical tool, X-ray spectroscopy, discovered a regularity in the X-ray spectra of the elements. The square root of the frequency of X-radiation plotted against the original number obtained from the periodic chart gave a straight line if provision were made for the gaps in the periodic chart. Experimental measurements were made for all known elements of ordinal numbers 1 through 79, and the experimentally determined ordinal numbers have since generally been referred to as atomic numbers. By determination of the atomic number of lanthanum, 57, and tantalum, 73, the total number of possible rare earths was determined for the first time, and Moseley was thus able to predict the total number of elements between hydrogen and uranium. At the time of Moseley, the remaining blanks were for the elements of atomic numbers 43, 61, 72, 75, 85, 87, and 91. Use of X-ray spectroscopy led to the discovery of hafnium, 72, rhenium, 75, and protactinium, 91, in natural ores, still leaving four blank spaces in the periodic chart.

Artificial Radioactivity. Artificially induced radioactivity was demonstrated for the first time by Curie and Joliot in 1934 (*7*).

The completion of the periodic system, and also its extension to include atomic numbers up to 98, was made possible by the artificial preparation of elements not existing in nature. Thus in recent years, the remaining blanks, 43, 61, 85, and 87, were filled in, and also the "transuranium" elements, 93, 94, 95, 96, 97, and 98 have been prepared without the previous identification of these elements in nature.

CLAIMS OF DISCOVERY

Various workers have claimed the discovery in nature of "eka-manganese," among them the following, each listed with the name suggested by the purported discoverer and the date of his claim (*9*):

Kern	Davym	1877
Hermann	Illmenium	1846
Barriere	Lucium	1896
Ogawa	Nipponium	1908

None of the preceding claims has been substantiated (*7*).

In 1925, a series of investigations by Noddack, Tacke, and Berg resulted in the report and claim of discovery of elements 43 and 75, identified by X-ray spectroscopic methods, claimed to have been found in platinum ores and columbite, and these elements were given the names masurium and rhenium, respectively (*2, 3, 9, 36, 37, 38, 39, 55*). Despite considerable investigation, this discovery of element 43 was never confirmed, and therefore has not been accepted. However, the discovery of rhenium, 75, by these workers has been recognized.

Føyne and Rosenqvist (*13*) reported a feeble α-activity in the HCl-insoluble impurities of commercial zinc, which they assumed to be possibly derived from the so-called masurium. This was also not confirmed.

In a meeting held in Amsterdam, the Netherlands, September 2–5, 1949, the International Union of Chemistry changed its name to the International Union of Pure and Applied Chemistry, and at the same time, officially approved the name technetium, Tc, to replace the former name masurium, Ma, proposed by Noddack and his co-workers for element 43 (*6*). This action gave approval to the suggestion of Perrier and Segrè (*45*), who proposed this name to indicate the fact that this element had been first prepared artificially by them in 1937.

PREDICTIONS

The existence of "eka-manganese" was expected since the first acceptance of the periodic system.

Moseley (*32*) showed the atomic number of molybdenum to be 42, and that of ruthenium to be 44, thus indicating that an element of atomic number 43 must be placed in the periodic chart in the same subgroup with manganese, and identifying the expected eka-manganese as element 43.

By comparison of isotopic numbers (I = A − 2Z), of the elements with odd atomic numbers, Brown (*3*) and Grégoire (*15*) predicted that the 97 and 99 isotopes of element 43 would be stable. However, Jensen (*20*) believed it to be doubtful that any stable nuclei of element 43 could exist, or that any β-active isotope of long life could exist.

From a study of the magnetic properties of the elements in the series Hf–Pt and Y–Pd, Mathiew (*28*) concluded that these elements do not exist as ions.

Loring (*9, 26*) predicted element 43 to consist of two isotopes, of mass numbers 99 and 101.

PREPARATION

A. By Artificial Radioactivity

Technetium was first prepared in the Berkeley cyclotron by Perrier and Segrè in 1937, and later in the Massachusetts Institute of Technology cyclotron and elsewhere, by bombardment of molybdenum with neutrons or deuterons according to the reactions (*42, 43, 49, 50, 52, 53, 54*):

$$_{42}Mo^{A} + {}_{0}n^{1} \rightarrow {}_{43}Tc^{A} + {}_{-1}\beta$$
$$_{42}Mo^{A} + {}_{1}H^{2} \rightarrow {}_{43}Tc^{A+1} + {}_{0}n^{1}$$

It was found that the new element resembled rhenium very closely, and was somewhat less similar to manganese (*24, 42, 46, 47, 53*). Maurer and Ramm (*29*) also prepared it by neutron bombardment of molybdenum, and found the isotope thus produced to have a half-life of 14.0 ± 0.3 minutes.

The deuteron bombardment of molybdenum produced $_{43}$Tc isotopes with half-lives of 90 days and 62 days (*4, 5, 51*).

Ferrier and Segrè (*23*) reported that bombardment of molybdenum with neutrons produced a radioelement of half-life of some months. They concluded that this activity was due to $_{43}$Tc, because the activity tends to follow manganese and rhenium, added as carriers, although the product is chemically distinct from either (*27*).

This technique of adding a carrier in order to determine the chemical nature of a radioelement present only in traces was developed by Perrier and Segrè (*23, 27*). Although it may lack the completeness possible when visible samples of the element are available, it makes possible at least the general characterization of an element present only in traces so minute that the only possible means of detecting its presence is the observation of its radioactivity. In the previous example, the manganese and rhenium added were not radioactive, and the new element was active but present in very small traces. By carrying out a series of chemical separations, involving the distinctive properties of manganese and rhenium, it was found that the fractions containing these carriers after the chemical separations showed distinct radioactivity. This result indicates that the element studied is similar in properties to these two elements, and therefore is a congener belonging to the same subgroup of the periodic chart. Element 43 is the only likely congener, and this fact served to identify the new element as number 43. At the same time, more radioactivity was found in the rhenium fractions than in the manganese fractions, thus indicating the greater similarity of the new element to rhenium than to manganese. This method does not make possible the establishment without doubt of exact chemical reactions, but does at least give a characterization which otherwise would be impossible.

In 1939, Seaborg and Segrè (*1, 51*) obtained detectable X-ray spectral lines due to element 43, although the amounts available were not sufficient for optical spectroscopy.

Technetium has also been prepared by α-bombardment of niobium, formerly called columbium (*6, 22, 50, 53*), and the technetium thus produced may be separated from the niobium by sublimation in a stream of oxygen (*54*), since the higher oxides of technetium are volatile.

$$_{41}Nb^{93} + {}_{2}\alpha^{4} \rightarrow {}_{43}Tc^{96} + {}_{0}n^{1}$$

An isotope of $_{43}$Tc is formed by β-decay of radiomolybdenum (*21*). The long-lived isotopes of technetium formed by deuteron bombardment of molybdenum give magnetic spectrogram lines corresponding to γ-rays of 87 and 184 k. e. v. Magnetic spectrograms of radioactive technetium contain two lines due to conversion in the K and L shells, with γ-ray energy of 129 k. e. v. (*21*).

Other transmutations induced by bombardment that result in the formation of $_{43}$Tc isotopes of short half-life are the following (*8, 10, 11, 19, 25, 42, 50, 51*):

$$_{44}Ru^{A} + {}_{1}H^{2} \rightarrow {}_{43}Tc^{A-2} + {}_{2}He^{4}$$
$$_{42}Mo^{98} + {}_{1}H^{1} \rightarrow {}_{43}Tc^{98} + {}_{0}n^{1}$$
$$_{42}Mo^{A} + {}_{1}H^{1} \rightarrow {}_{43}Tc^{A} + {}_{0}n^{1}$$

The last reaction produces radioisotopes of undetermined mass numbers and half-lives 110 hours, 18 sec., and 2 days (*10, 11, 50, 51*). The Tc^{98} isotope produced in the second reaction has a half-life of 2.7 hours (*8, 22, 50, 54*).

B. By Nuclear Fission

More than eight radioactive isotopes have been identified among the fission products of uranium (*17*). Among these, Hahn and Strassman (*44*) recognized three isotopes of molybdenum produced by fission of uranium by neutron bombardment: $_{42}Mo^{101}$ of 14 minute half-life; $_{42}Mo^{99}$ of 67 hour half-life; and an isotope $_{42}$Mo of undetermined mass number and 12 minute half-life. Each of these decomposes by β-emission to form $_{43}$Tc (*47, 50, 55*).

$$_{42}Mo^{101} \rightarrow {}_{43}Tc^{101} + {}_{-1}\beta$$
$$_{42}Mo^{99} \rightarrow {}_{43}Tc^{99} + {}_{-1}\beta$$
$$_{42}Mo^{A} \rightarrow {}_{43}Tc^{A} + {}_{-1}\beta$$

The $_{43}Tc$ produced from the 12-minute $_{42}Mo$ is stated to be "very short lived" (*16*), but the decomposition products are not stated. The isotope $_{43}Tc^{99}$ is reported to be long-lived, but $_{43}Tc^{101}$ is β-active with 14-minute half-life (*18*).

$$_{43}Tc^{101} \rightarrow {}_{44}Ru^{101} + {}_{-1}\beta$$

Maurer and Ramm (*30*) also reported the production of radioactive molybdenum by slow neutron bombardment of uranium and that one of the products of β-decay of the molybdenum is an isotope of $_{43}Tc$. Absorption measurements yielded the upper limit of the β-spectrum of this isotope as approximately 400 k. e. v. Peed (*40*) and co-workers made X-ray emission spectra photographs of $_{43}Tc$ produced by uranium fission.

Kozima (*23*) reported that slow neutron bombardment of molybdenum yields $_{43}Tc^{101}$, having a half-life of 9 minutes, and β-energy of 1.4×10^6 e. v.

Other workers (*5, 14, 24, 33, 34, 35, 48, 51*) have reported $_{43}Tc$ isotopes of half-lives 2×10^6 years, 10^6 years, 3×10^5 years, 40 years, 90 days, 80 days, and 50 days, in addition to the much shorter-lived isotopes mentioned above. None of the preceding methods produced visible samples, and the quantities of technetium were too small for any but radiochemical studies.

ISOLATION

Flagg and Bleidner (*12*) developed a chemical method for isolating technetium as a pure compound, and as pure technetium metal. The technetium was produced by bombardment of molybdenum plates by deuterons, and the technetium was separated chemically as follows. The molybdenum plates after bombardment were dissolved in aqua regia, excess HNO_3 was added, and the solution was evaporated dry under an infrared lamp, adding HNO_3 as the solution evaporated. The evaporation was repeated until the residue of MoO_3 was perfectly white. The white residue was taken up with 15 *M* aqueous ammonia, and after the solution was diluted and acidified to methyl orange, ammonium acetate was added, and the solution was heated to boiling. Then 1 *N* $AgNO_3$ was added, about 10 per cent in excess. The precipitated Ag_2MoO_4 was filtered and washed with 0.5 per cent $AgNO_3$. The excess Ag^+ was removed from the filtrate by addition of NH_4I. Next aqua regia was added, and the solution was evaporated almost to dryness. Finally concentrated H_2SO_4 was added and the solution was evaporated to SO_3 fumes. The residue was diluted and filtered. It was assumed that this treatment yielded technetium in its highest stable valence state, probably +7, by analogy with manganese and rhenium. Technetium metal was then deposited electrolytically. Quantities produced amounted to no more than an invisible radioactive film on the electrode.

Technetium may be recovered from molybdenum that has been bombarded by neutrons by a method devised by Perrier and Segrè (*41, 43*). The bombarded molybdenum was treated with dilute aqueous ammonia. Most of the technetium and a few milligrams of molybdenum are dissolved, free of rhenium. The technetium is separated from the molybdenum by precipitating the molybdenum with oxyquinoline.

Perrier and Segrè (*42*) also used the following method to isolate technetium from the surface of molybdenum plates that have been bombarded with neutrons or deuterons. After the bombardment, 200 mg. of the molybdenum metal was dissolved in aqua regia, 5 mg. rhenium was added as a carrier, and the solution was evaporated to dryness on a steam bath. The residue was extracted with water and dissolved in ammonia. The solution, containing the technetium, was saturated with H_2S, manganese was added as a carrier, and the solution was allowed to stand overnight. The technetium precipitates as the sulfide, black.

The first visible samples of technetium were produced at the Clinton Laboratories of the Atomic Energy Commission. Parker, Reed, and Ruch (*39*) succeeded in isolating milligram amounts of technetium from uranium fission. All operations were carried out by remote control, and the apparatus was surrounded by concrete walls. After bombardment of uranium slugs with neutrons, the product was dissolved in 37 per cent HCl, to produce a UCl_4 slurry, which was oxidized with 30 per cent H_2O_2 to produce UO_2Cl_2, and then treated with liquid bromine to remove the excess H_2O_2. To the UO_2Cl_2 thus produced, $PtCl_2$ was added, and the solution was saturated with H_2S. The technetium precipitated as the sulfide along with PtS as carrier. The combined precipitate was dissolved in 30 per cent H_2O_2 and 19 per cent NH_3 in aqueous solution, and this solution was evaporated nearly to dryness. The pink residue probably contains TcO_3 and Tc_2O_7. Sulfuric acid, 18 *N*, was added, and the mixture was distilled. Technetium distilled off as the oxide.

The mass number of 99 for this isotope was determined on a Nier-type apparatus, and the half-life was determined by direct weighing of the sulfide as 5.5×10^5 years. Aluminum absorption curves showed a β-energy of 0.31 ± 0.03 m. e. v.

CHEMICAL PROPERTIES

Precipitation of the Sulfide. Parker and co-workers (*39*) determined that a solution of 100 ml. containing 0.3 mg. Tc precipitated completely without a carrier when H_2S was passed through a dilute acid (1–4 *N* HCl) solution until saturated. The precipitate was brownish-black, coagulated on cooling, and is probably Tc_2S_7. The sulfide is readily filtrable on fine sintered glass.

Technetium sulfide may also be precipitated from HCl solution (0.4–5.0 *N*) using Re or Pt as coagulant (*41, 43*), the precipitation being complete in 24 hours. In 10 *N* HCl, technetium sulfide does not precipitate. Sulfides of technetium and rhenium are both volatile at 100° C. in a current of chlorine.

Technetium sulfide is also precipitated by hydrogen sulfide in ammoniacal solution (*43*).

Solubility of the Sulfide. The sulfide, Tc_2S_7, is readily soluble in cold aqueous ammonia-H_2O_2 mixture, to produce a faint pink solution (*39*). Evaporation of the solution produces a pink crystalline residue, containing NH_4TcO_4. Continued heating changes the residue to a brown amorphous mass (*39*).

Technetium sulfide is also soluble in cold aqueous ammonia, without the addition of H_2O_2 (*42*). This property is analogous to that of rhenium sulfide. The sulfide is also stated to be insoluble in ammonium polysulfide (*42*). This last observation is surprising, and is not in agreement with the other observations mentioned above, indicating the definite acidity of both the oxide and sulfide. If the sulfide dissolves in aqueous ammonia, it seems strange that it will not dissolve in "ammonium polysulfide," which always contains a considerable excess of ammonia. Furthermore, the ammonium polysulfide is a strong oxidizing agent, comparable to hydrogen peroxide, and would tend to oxidize the technetium, or to keep it in its higher valence, in which both the oxide and the sulfide have been shown to be decidedly acidic.

Separation. Addition of concentrated sulfuric acid and distillation removes technetium as the volatile oxide, Tc_2O_7, and separates technetium from all known contaminants except rhenium.

Technetium may be separated from rhenium by adding perchloric acid and distilling. Technetium distills more readily. After distilling about half of the solution, the distillate is relatively pure technetium, and all of the rhenium remains in the residue (*39*).

Technetium is precipitated by "niton," diphenylendoanilohydratriazole (*43*).

Technetium is separated from molybdenum by precipitating molybdenum with oxyquinoline (*41*, *43*).

Coprecipitation. Most metals which form acid-insoluble sulfides (Group 2 in the Noyes qualitative analysis scheme) coprecipitate technetium. Platinum coprecipitates technetium quantitatively from dilute acid solution (*39*).

In ammoniacal solution, technetium sulfide is coprecipitated with manganese, iron, and zinc (*43*).

Spectrographic Detection. The principal spectral lines, free from interference, that are useful for qualitative identification of Tc are those of wave lengths 3237.0, 4031.1, 4088.3, 4095.3, 4261.9, and 4297.2 Å. (*39*).

Redox Potential. Flagg and Bleidner (*12*), after producing a solution containing technetium in its highest valence state, electrolyzed the solution in a Pregl micro electrolytic cell in a sulfuric acid solution of pH 2.36, using a platinum gauze cathode and a saturated calomel half-cell as the reference electrode. After applying a measured potential, the solution was withdrawn from the cell with a pipet, and its activity was measured with a Geiger counter, previously calibrated with uranium nitrate. This gave a measure of the amount of technetium remaining in solution, and the difference between that remaining and that originally present gave a measure of the amount of technetium precipitated. No activity was found on the anode, thus indicating that there is no anodic decomposition analogous to the deposition of MnO_2 on the anode during electrolysis of manganese solutions. The amount of technetium deposited was plotted against the electrode potential to indicate the potential at which decomposition begins. In the solution used, the decomposition potential was -0.146 v. Using the estimated value of $[TcO_4^-] = 10^{-12}\ M$, and $[H^+] = 10^{-2.36}\ M$, and substituting in the Nernst equation, this potential corresponds to $E^\circ = -0.41$ v. for the equilibrium

$$Tc_{(s)} + 4H_2O \rightleftharpoons TcO_4^- + 8H^+ + 7e^-$$

This value is intermediate between those for manganese and rhenium

$$E^\circ(Mn \rightleftharpoons MnO_4^-) = -0.78 \text{ v.}$$
$$E^\circ(Re \rightleftharpoons ReO_4^-) = -0.15 \text{ v.}$$

From the accepted valence of manganese in permanganate and of rhenium in perrhenate, this value of E° ($Tc \rightleftharpoons TcO_4^-$) gives at least forensic confirmation of the assumption of the $+7$ oxidation state for technetium in the compound produced in this investigation, in addition to the prediction by analogy from the periodic system.

It will be noticed that the value of E° for Tc is closer to that for Re than to that for Mn.

Action of Reducing Agents on TcO_4^-. The anion containing technetium in the $+7$ valence state (the pertechnate ion) in acid solutions (H_2SO_4) was treated (*12*) with the following reducing agents: Zn, Sn, Ni, Pb, Cu, Hg^I, concentrated HCl solution, and 20 per cent $SnCl_2$ in 1:1 HCl solution.

All of the above metals produced a quantitative removal of the radioactivity of the original solution, indicating that the TcO_4^- is reduced, either to Tc, or to an insoluble oxide.

Chromatographic analysis was used for the liquid reducing agents to determine whether the technetium is anionic or cationic. Both concentrated HCl and $SnCl_2$ solution changed the radioactivity from anionic to cationic, thus indicating that TcO_4^- is reduced to a cation, probably Tc^{++}, although no direct evidence is given to determine the valence change in the reaction.

If to a solution containing radioactive heptavalent technetium (pertechnate ion), permanganate ion is added, and the solution is reduced with alcohol, the manganese is reduced to MnO_2. None of the activity is found on the MnO_2. This indicates that pertechnate is not reduced to TcO_2 by alcohol (*42*).

Technetium and Rhenium. Most chemical reactions of technetium are similar to those of rhenium. One distinction is reported by Perrier and Segrè (*42*). When moist HCl is passed through 80 per cent H_2SO_4 solution for one and a half hours, all rhenium appears in the distillate, and all the radioactivity (Tc) remains in the residue.

When manganese and rhenium are added to solutions

containing radioactive technetium, the activity follows the rhenium more closely than it follows manganese (19).

The chemical properties of technetium are summarized in Table 1.

TABLE 1

Substance	*Reagent*	*Product*
Tc	HNO_3/HCl	Tc_2O_7
Tc	HNO_3/H_2O_2	Tc_2O_7
Tc	HCl	Tc^{++}
Tc_2O_7	$NH_{3(aq.)}$	TcO_4^-
$HTcO_4$	Evaporation	$Tc_2O_{7(s)}$
$HTcO_4$	H_2SO_4 (conc.) >100 °C.	$Tc_2O_{7(g)}$
$HTcO_4$	$HClO_4$ (>100 °C.)	$Tc_2O_{7(g)}$
Tc^{++}	H_2S/H^+	$TcS_{(s)}$
TcO_4^-	H_2S/H^+	Tc_2S_7
TcS	$H_2O_2/NH_{3(aq.)}$	TcO_4^-
Tc_2S_7	$H_2O_2/NH_{3(aq.)}$	TcO_4^-
Tc_2S_7	$NH_{3(aq.)}$	TcS_4^-
TcO_4^-	Zn/H^+	Tc
TcO_4^-	Sn/H^+	Tc
TcO_4^-	Ni/H^+	Tc
TcO_4^-	Pb/H^+	Tc
TcO_4^-	Cu/H^+	Tc
TcO_4^-	Hg/H^+	Tc
TcO_4^-	HCl (conc.)	Tc^{++}
TcO_4^-	$SnCl_2$ (20%)	Tc^{++}

NUCLEAR PROPERTIES

The preparation and nuclear properties of technetium isotopes are listed in Table 2.

TABLE 2

Isotope	*Preparation*	*Activity (emission)*	*Half-life*
$_{43}Tc^{91}$	$_{42}Mo^{91}(p, n)$	β^-	18 sec.
$_{43}Tc^{93}$	$_{42}Mo^{93}(p, n)$	..	2 days
$_{43}Tc^{95}$	...	β^+	53 min.
$_{43}Tc^{96a}$	$_{41}Nb^{93}(\alpha, n)$	β^+	2.7 hr.
$_{43}Tc^{96a}$	$_{42}Mo^{96}(p, n)$	γ, K	4 days
$_{43}Tc^{99b}$	$_{42}Mo^{99} - \beta^-$	β^-	1×10^6 hr. (5.5×10^5 yr.)
$_{43}Tc^{99b}$	...	γ, IT	6.6 hr. (5.9 hr.)
$_{43}Tc^{101}$	$_{42}Mo^{101} - \beta^-$	β^-	9 min.
$_{43}Tc^{103}$	...	β^-	1 min.
$_{43}Tc^{107}$	...	β^-	1.5 min.
$_{43}Tc^{A}$	$_{42}Mo^{A-1}(d, n)$	..	90 days
...	$_{42}Mo^{A}(n, \beta^-)$	β^-, γ	14 min.
...	$_{42}Mo^{A}(p, n)$	..	110 hr.
...	$_{42}Mo^{A} - \beta^-$	..	Very short
...	$_{44}Ru^{A+2}(d, \alpha)$	..	Short
$_{43}Tc^{A}$	...	..	50 days; 80 days; 40 yr.; 3×10^5 yr.; 2×10^6 yr.

[a] Nuclear isomers.
[b] Nuclear isomers.
A = undetermined mass number.
IT = isomeric transition.
K = K-electron capture.

LITERATURE CITED

(1) Abelson, P. H., *Phys. Rev.*, **56**, 753–7 (1939).
(2) Berg, O., *Z. angew. Chem.*, **40**, 2546 (1927).
(3) Brown, H., *Phys. Rev.*, **53**, 846 (1938).
(4) Cacciapuoti, B. N., *ibid.*, **55**, 110 (1939).
(5) Cacciapuoti, B. N., and S. Segrè, *ibid.*, **52**, 1252 (1937).
(6) *Chem. Eng. News*, **27**, 2996–9 (1949).
(7) Curie, I., and F. Joliot, *Nature*, **133**, 201 (1934).
(8) Delasso, Ridenhour, Sheer, and White, *Phys. Rev.*, **55**, 113 (1939).
(9) Druce, J. G. F., *Chem. & Ind.*, **60**, 729–30 (1941).
(10) DuBridge, Barnes, Wiig, Buck, and Strain, *Phys. Rev.*, **53**, 326 (1938).
(11) Ewing, Perry, and McCreary, *ibid.*, **55**, 1138 (1936).
(12) Flagg, J. F., and W. E. Bleidner, *J. Chem. Phys.*, **13**, 269–76 (1945).
(13) Føyne, E., and I. T. Rosenqvist, *Tids. Kjemi Bergvesen*, **18**, 64 (1928).
(14) Glendenin, L. E., CC-1050, Nov. **1943**, p. 9.
(15) Grégoire, R., *Compt. rend.*, **206**, 1477–8 (1938).
(16) Hahn, O., and F. Strassman, *J. Physik*, **117**, 789 (1941).
(17) Hahn, O., and F. Strassman, *Abhandl. preuss. Akad. Wiss. Math.-Naturw. Klasse*, No. 3 (1942), No. 12 (1944).
(18) Hahn, O., and F. Strassman, *Naturw.*, **29**, 369 (1941).
(19) Irvine, J. W., Jr., *Chem. Rev.*, **23**, 77–86 (1936).
(20) Jensen, H., *Naturw.*, **26**, 381 (1938).
(21) Kalbfell, D. C., *Phys. Rev.*, **54**, 543 (1938).
(22) King, Henderson, and Risser, *ibid.*, **55**, 1118 (1939).
(23) Kozima, S., *ibid.*, **57**, 750 (1940).
(24) Lincoln, D. C., and W. H. Sullivan, CN-3440, Oct. 24, **1945**.
(25) Livingood, *Phys. Rev.*, **50**, 425 (1936).
(26) Loring, *Chem. News*, **132**, 407 (1926).
(27) McKay, H. A. G., *Chem. & Ind.*, **58**, 762 (1939).
(28) Mathiew, J. P., *Cahiers phys.*, **22**, 33–6 (1944).
(29) Maurer, W., and W. Ramm, *Naturw.*, **29**, 368 (1941).
(30) Maurer, W., and W. Ramm, *Z. Physik*, **119**, 334–51 (1942).
(31) Mendeleev, D., *Ann.*, **8**, 133–229 (1872).
(32) Moseley, H. G. J., *Phil. Mag.*, **26**, 1024 (1913).
(33) Motta, E. E., G. E. Boyd, and A. R. Brosi, *Phys. Rev.*, **71**, 210 (1947).
(34) Motta, E. E., G. E. Boyd, and Q. V. Larson, *ibid.*, **72**, 1268 (1947).
(35) Motta, E. E., Q. V. Larson, and G. E. Boyd, NonC-99, Apr. 1, **1947**.
(36) Noddack, W., and I. Noddack, *Z. angew. Chem.*, **40**, 250–4 (1927).
(37) Noddack, W., I. Tacke, and O. Berg., *Naturw.*, **13**, 567 (1925).
(38) Noddack, W., I. Tacke, and O. Berg, *Abhandl. Berlin. Akad. Wiss. Math.-Naturw. Klasse*, pp. 400–9, June 11, **1925**.
(39) Parker, G. W., J. Reed, and J. W. Ruch, AECD-2043, Jan. 9, **1948**.
(40) Peed, W. F., B. G. Saunders, and L. E. Barkhart, *Phys. Rev.*, **73**, 347 (1945).
(41) Perrier, C., and E. Segrè, *Atti Accad. naz. Lincei. Classe sci. fis. mat. e nat.*, **27**, 579–81 (1938).
(42) Perrier, C., and E. Segrè, *J. Chem. Phys.*, **5**, 712–6 (1937).
(43) Perrier, C., and E. Segrè, *ibid.*, **7**, 155–6 (1939).
(44) Perrier, C., and E. Segrè, *Nature*, **140**, 193–4 (1937).
(45) Perrier, C., and E. Segrè, *ibid.*, **159**, 24 (1947).
(46) Sagane, R., *Phys. Rev.*, **57**, 1179 (1940).
(47) Sagane, R., Kojima, Miyamoto, and Ikawa, *ibid.*, **57**, 750, 1180 (1940).
(48) Schumann, R. P., CC-3434, Feb. 7, **1946**.
(49) Seaborg, G. T., *Am. Scientist*, **36**, 361–76 (**1948**).
(50) Seaborg, G. T., *Chem. Rev.*, **27**, 199–285 (1940).
(51) Seaborg, G. T., and E. Segrè, *Phys. Rev.*, **55**, 808 (1939).
(52) Segrè, E., *Nature*, **143**, 460 (1939).
(53) Segrè, E., *Sci. Mon.*, **57**, 12–6 (1943).
(54) Stewart, *Phys. Rev.*, **56**, 674 (1939).
(55) Tacke, I., *Z. angew. Chem.*, **38**, 794, 1157–60 (1925).

A SIMPLE METHOD FOR THE PREPARATION OF TERTIARY AMINES[1]

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Some time ago, in this laboratory we had need for rather large quantities of certain tertiary amines which were not available commercially. In addition, at that time, no intermediates suitable for the preparation of these amines were available other than the alkyl halides. Even though almost invariably undergraduate organic texts imply that reaction of alkyl halides with ammonia is not a suitable method for preparation of amines because of the difficulty of side reactions and separation of products, we were limited to this approach.

A number of preparations[2,3] of compounds of the type desired have been reported but these processes usually involve the use of high pressure in an autoclave as the result of the reaction of the alkyl halide with 28 per cent aqueous ammonia or with anhydrous ammonia. Satisfactory yields were obtained in this laboratory by reaction of the alkyl halides with 28 per cent aqueous ammonia in an autoclave but because of the limited capacity of the equipment available (a maximum yield of about 30 g. per run) we were obliged to exploit other possibilities.

Since the capacity of laboratory equipment suitable for working at atmospheric pressure is essentially unlimited, we adopted the method described in detail below in which the 28 per cent aqueous ammonia was diluted to a concentration equal to the solubility of ammonia at the temperature desired for carrying out the reaction with the alkyl halide. After a few simple experiments in which the ratio of ammonia to alkyl halide was varied to establish optimum conditions for formation of the tertiary amine, we were able to prepare these amines in satisfactory yields and in almost unlimited quantities.

Because of the simplicity of conditions and equipment employed in this reaction, and because of the discouraging influence of most organic texts toward use of this reaction, it appears that the information may possibly be useful for adoption by high-school or college laboratories of limited equipment either as a laboratory experiment in the preparation of amines, or in the preparation of commercially unavailable amines required for research.

EXPERIMENTAL

Triallyl Amine. The procedure for preparation of triallyl amine will illustrate the general procedure used. In a 3-liter three-necked flask equipped with stirrer, condenser, thermometer, and dropping funnel 274 g. ($4\frac{1}{2}$ moles) of 28 per cent aqueous ammonia was diluted with 1050 g. of water (resulting concentration, 7.4 g. NH_3 per 100 g. water, equivalent to solubility at 100°). This solution was heated on a steam bath to 75° and 363 g. (3 moles) of allyl bromide added through the dropping funnel at such a rate that gentle reflux was maintained throughout the addition. After addition was complete stirring and heating at this temperature were continued for three hours. After cooling, the oily layer which separated was removed and dried over solid sodium hydroxide. The cold aqueous solution was saturated with sodium hydroxide and the resulting oily layer which separated was added to the main product. After drying for twenty-four hours over solid sodium hydroxide the amines were distilled through an efficient column.

Trimethallyl amine and tri-(2-chloroallyl)amine were prepared by similar procedures using methallyl chloride and 2-chloroallyl chloride, respectively. Results of these preparations are recorded in the accompanying table.

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Yields of Amines

Reactant	*Yield of 1° amine, g.*	*B.P., °C.*	*Yield of 2° amine, g.*	*B.P., °C.*	*Yield of 3° amine, g.*	*B.P., °C.*	*% of theoretical yield 3° amine*
Allyl bromide	11.5	56–8	24	111–3	78.3	154–6	57.2
Methallyl chloride	10.5	70–73	42.3	144–6	24.7	184–9	13.7
2-Chloroallyl chloride	Neg.	...	Neg.	...	175.7	120–2/10 mm.	73.5

[1] This work was done under the sponsorship of the Office of Naval Research, Contract N7-onr-346.

[2] Grosheintz, *Bull. soc. chim.*, 31, 391 (1879).

[3] Tamele, Ott, Marple, and Hearne, *Ind. Eng. Chem.*, 33, 117 (1941).

EXPERIMENTS WITH ION-EXCHANGE RESINS[1]

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WITHIN the past several years, there has been considerable development in the production of new synthetic ion-exchange resins. This development has been accompanied by numerous applications of these resins to various problems in research. The commercial importance of the resins makes it highly desirable that the student in the chemistry and in the chemical engineering curriculum obtain some familiarity with their fundamental properties and principles of operation and with the techniques involved in their use.

While ion-exchange methods themselves are not new, the current interest in this tool is emphasized by the recent appearance of numerous articles on this subject in the various journals. The solution of such problems as the isolation and purification of certain rare earth (*1*, *2*, *3*) and transuranic (*4*, *5*) elements has been accomplished (*6*). Spedding has described the pilot plant scale separation of the rare earths (*7*). Ion-exchange resins have aided in the isolation of antibiotics (*8*). In the field of analytical chemistry, the use of resin techniques can be applied to the elimination of interfering substances (*9*). A general, popular review of the uses of ion-exchange resins is given by Walton (*10*). Several other articles have recently appeared in the JOURNAL OF CHEMICAL EDUCATION on this subject (*11*, *12*).

Student experiments involving techniques employing ion-exchange resins are now quite feasible as a result of the availability of high-grade, high-capacity resins in laboratory quantities. These experiments may be appropriately introduced into the semiadvanced inorganic or physical chemistry program. Ion-exchange methods provide the field of inorganic chemistry with a separation process quite comparable in significance to that of distillation in organic chemistry. It is the purpose of this paper to describe suitable experiments which are performed by the senior chemistry students in our laboratories.

Previously, Daniels, *et al.*, in their "Experimental Physical Chemistry" (*13*), have suggested the use of ion-exchange resins in adsorption equilibrium experiments similar to the familiar study of the adsorption of acetic acid on charcoal. However, as the latter system has already been investigated by our junior students, little would be gained by having them perform an almost identical experiment. An experiment involving the column separation (similar to a chromatographic separation) of two ions suggests itself as suitable for ion-exchange studies by the students. An experiment of this type is completely different from those normally performed in the undergraduate courses. We have found that it does stimulate the interest of the student.

In order to choose an appropriate system for the study, one must first consider which analytical tool it is most desirable to employ in following the elution curves. We have chosen, for this purpose, volumetric titration in order that the student can conveniently and quickly analyze the large number of samples obtained during the course of the experiment. This also serves, partially at least, to correct the situation in the physical chemistry laboratory where chemical analytical methods are almost completely de-emphasized in favor of physical tools. Other institutions may wish to use other methods, *e. g.*, colorimetric or radiochemical methods, for the analyses.

COPPER-SILVER SEPARATION

The ions of copper and silver have been found to provide a suitable system for these studies. The silver ion is readily titrated with potassium thiocyanate using ferric alum as the indicator while an iodometric titration of copper with sodium thiosulfate can easily be carried out.

Figures 1 and 2 represent, respectively, the data obtained for the elution of copper and silver ion alone from a 50-cm. column of Amberlite IR 100-H resin. This is the hydrogen form of the resin. The column is conveniently made by packing an ordinary stopcock buret with the resin. The stopcock, then, provides a means of regulating the flow of material through the column.

The ion (as silver or cupric nitrate in 0.1 *N* solution) is adsorbed at the top of the column and washed with distilled water. The effluent should test negatively for

[1] Presented at the 118th Meeting of the American Chemical Society, Chicago, Illinois, September 3–8, 1950.

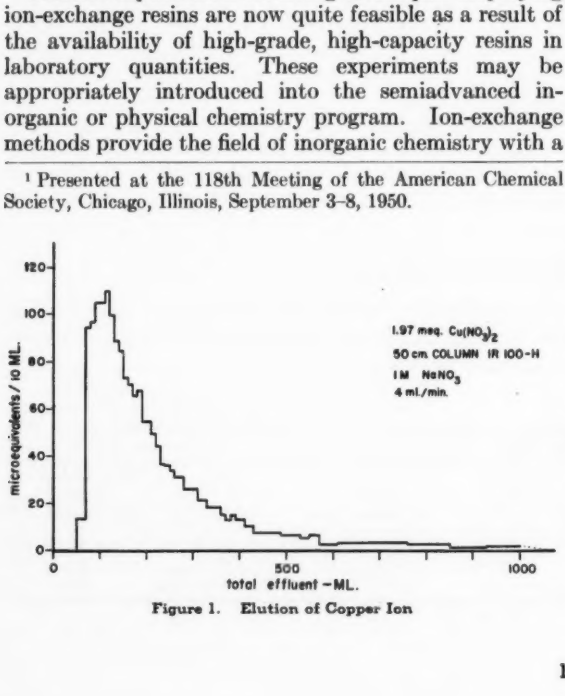


Figure 1. Elution of Copper Ion

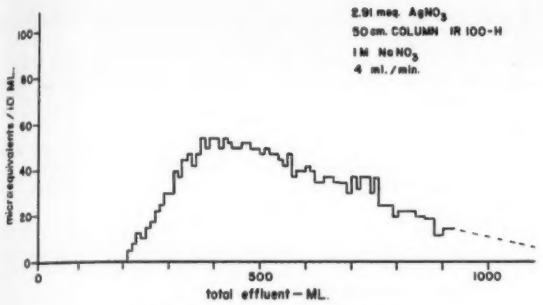


Figure 2. Elution of Silver Ion

both ions. The copper and silver ions are then eluted by passing 1 *M* sodium nitrate solution through at the rather rapid rate of 3 to 4 ml. per minute. The concentration of silver ion in the effluent is determined by titrating the subsequent 10-ml. samples with 0.05 *N* potassium thiocyanate. In the case of copper, potassium iodide is added to the sample, and the liberated iodine is titrated with 0.05 *N* sodium thiosulfate. The iodine serves as its own indicator in this titration. Toward the end of the elution, it will be found necessary to take samples larger than 10 ml. in order to obtain enough ion for the analysis.

Because the analysis yields the amount of ion contained in a definite sample, the data are plotted in the form of a histogram rather than as a smooth curve. If the sample size differs from 10 ml., then the titration must be calculated in terms of the amount of ion contained in 10 ml. (or some other suitable volume). This value is then spread over the entire volume taken. The relatively great scatter of the experimental points results from the fact that only a few milliliters of titrant are required for each sample. This is necessary since the amount of ion is limited by the capacity of the resin. It also serves to speed the analysis considerably —a necessary requirement since the available time is severely limited. It is believed that this sacrifice of precision is not seriously detrimental to the experiment, since it is only desired to show the general nature of the elution curves.

Figure 3 represents the separation of the binary copper-silver system. The curves are obtained as before with the exception that the effluent sample is split in half before the titrations are carried out. The ferric alum indicator used in the silver titration interferes in the copper titration, making it necessary to use a separate sample for each component.

It is seen that in this separation the copper is eluted before the silver. In general, the curves for the copper ion are much steeper and less drawn out than in the case of silver. In the curve of Figure 3, 65 per cent of the copper ion is eluted without any trace of silver. This effect, of course, increases with longer columns and decreases with shorter columns. The elution of copper before silver appears to be anomalous since the lower valence states are normally expected to be held to the resin less strongly than the higher valence states. However some difficulties are undoubtedly involved in this case due to the complexing of the ions.

In performing ion-exchange experiments, one must be careful not to attempt to separate too great a quantity of material. If the resins become saturated with the ions the separation processes will not work. The maximum exchange capacity of the resin employed here is approximately 1 milliequivalent per ml. As mentioned before, this severely limits the analytical techniques which it is possible to employ.

The following approximate values for the various variables are suggested for the experiments. None of the quantities is critical, so some variation is possible.

Amount of ion	3 milliequivalents
Column length	50 cm.
Column cross section	1 $cm.^2$
Elutrient	1 *M* sodium nitrate
Rate of elution	3 to 4 ml./min.
Sample size	10 ml.
Titrant concentration	0.05 *N*

In the experiments described here, the student is required to perform numerous titrations (50 or more). He therefore becomes accustomed to performing titrations in a routine manner, something which is normally not considered in the analytical laboratory. The appearance of a large amount of data during the course of the afternoon also serves to create interest in the experiment. The determination of one binary separation curve is sufficient to keep a pair of hard-working students quite busy for a full afternoon laboratory session. If less time is available, it may be desirable to have the students study the elution of a single ion. The elution curves for different ions obtained by different students under similar conditions can then be compared as indicated by the comparison of Figures 1 and 2.

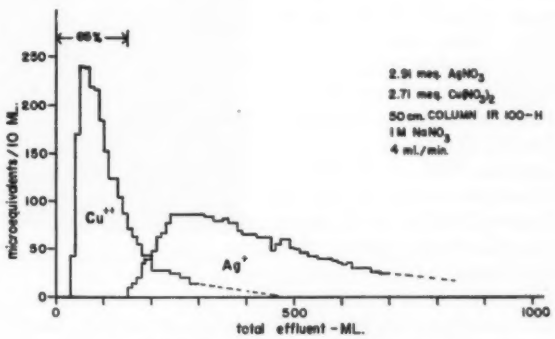


Figure 3. Elution of Silver and Copper Ions

Important from the instructional point of view is the fact that the experiments themselves are almost entirely foolproof and require, therefore, little supervision. It should be mentioned that the Amberlite resins are available in pound quantities at reasonable cost. Although the resins may be regenerated, we prefer to have each student start with fresh resin.

ACKNOWLEDGMENT

We wish to thank Dr. Paul Klaas of the Rohm and Haas Co. for supplying certain resins for our studies.

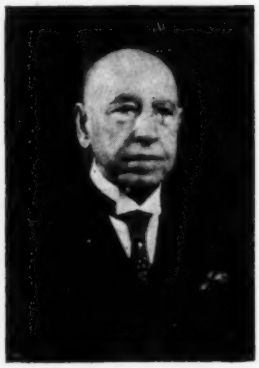
LITERATURE CITED

(1) KETELLE, B. H., AND G. E. BOYD, *J. Am. Chem. Soc.*, **69**, 2800 (1947).
(2) SPEDDING, F. H., A. F. VOIGHT, E. M. GLADROW, AND N. R. SLEIGHT, *ibid.*, **69**, 2777 (1947).
(3) HARNS, D. H., AND E. R. TOMPKINS, *ibid.*, **69**, 2792 (1947).
(4) STREET, K., JR., AND G. T. SEABORG, *ibid.*, **72**, 2790 (1950).
(5) THOMPSON, S. G., B. B. CUNNINGHAM, AND G. T. SEABORG, *ibid.*, **72**, 2799 (1950).
(6) DANIELS, F., "Outlines of Physical Chemistry," John Wiley and Sons, New York, **1948**, p. 553.
(7) SPEDDING, F. H., *et al.*, *J. Am. Chem. Soc.*, **69**, 2812 (1947).
(8) DOERY, H. M., AND E. C. MASON, *Anal. Chem.*, **22**, 1038 (1950).
(9) KUNIN, R., *ibid.*, **21**, 87 (1949).
(10) WALTON, H. F., *Sci. Am.*, **183**, No. 5, 48 (1950); see also E. R. TOMPKINS, J. CHEM. EDUC., **26**, 32, 92 (1949).
(11) CASTKA, J. F., AND J. CRANE, J. CHEM. EDUC., **27**, 673 (1950).
(12) PETERSON, S., J. CHEM. EDUC., **28**, 22 (1951).
(13) DANIELS, F., J. H. MATHEWS, J. W. WILLIAMS, P. BENDER, G. W. MURPHY, AND R. A. ALBERTY, "Experimental Physical Chemistry," McGraw-Hill Book Co., Inc., New York, **1949**, p. 247.

GEORGES DENIGÈS

RALPH E. OESPER
University of Cincinnati, Cincinnati, Ohio

NOT many chemists live into their tenth decade and far fewer continue active work in the laboratory after reaching four score and ten. However, longevity and exceptional retention of working powers do not in themselves constitute claims to lasting distinction; what is done with these exceptional opportunities is the main item.



Georges Denigès at the age of 90

Georges Denigès was born on December 25, 1859, at Bordeaux, and he has spent most of his life in his native city. Like many of the early French chemists, he came to chemistry through medicine. After receiving his M.D. degree at Bordeaux in 1884, with a thesis, "Contribution à l'acidité de l'urine," he went to Paris for training in science. His Docteur ès sciences (1891), for which he offered the dissertation, "Recherches sur les combinaisons de sulfites metalliques avec les amines aromatiques," was followed by a third degree, Pharmacien superieur (1892), with the thesis, "Contribution a l'étude des lactoses." He also secured the certificate "agrégé de chimie medicale," *i. e.*, he was officially declared competent to teach this subject. In 1898 the University of Bordeaux created for him a chair of biological chemistry, and he filled this post until 1930, when he reached the legal retiring age. His retirement by no means marked the close of his scientific career; as honorary professor he has continued to work and publish. Despite his advanced age he still goes to the laboratory regularly.

Professor Denigès has put out almost 600 publications since his first paper appeared in 1880. These include 50 communications presented to the Academie des Sciences and inserted in its *Comptes rendus*. Special attention is merited by six important papers in the *Annales de Chimie:* (1) A new cyanimetric method and its applications; (2) New classes of mercuric organic compounds and their applications; (3) A critical and experimental study of the localization of arsenic; (4) A chronometric method applied to quantitative analysis; (5) Analytical reactions of some organic functions based on their transformation into aldehydic and ketonic derivatives; (6) Ceruleo-molybdimetry, applicable in microchemistry to the determination of phosphate and arsenate. A series of studies of triazol should also be noted.

The bulk of his work has dealt with many and varied aspects of analytical chemistry. His contributions to microchemistry are especially important; they extend into all fields of inorganic, organic, and biological chemistry. For example, 125 notes, etc., have appeared on microcrystalloscopy.

His books include "Leçons d'Analyse Qualitative sur les Metalloides et leurs Principaux Derivés," "Précis de Chimie Analytique," "Determination Rapide des Concretions et Sables Urinaires."

Georges Denigès is an *officier* of the Legion of Honor. He has been honored by the Academie des Sciences by the award of the Berthelot Medal and the Grand Prix Lacaze for chemistry. In 1897 he received the Prix Buignet of the Academie de Medicine. His memberships include the Academies of Science, of Medicine and Pharmacy, the Belgian Academy of Medicine, etc.

VAPOR DIFFUSION METHODS IN QUALITATIVE AND QUANTITATIVE ANALYSIS[1]

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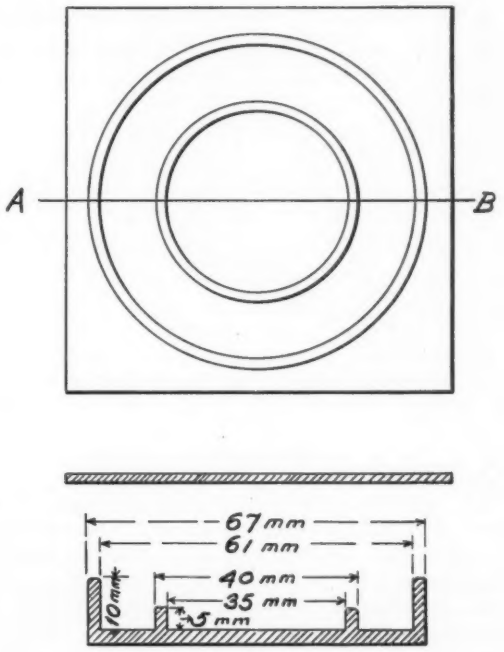
ANALYTICAL procedures of high precision based on use of the "Conway Unit" have been described by several investigators.[2] Most of the applications reported have been in connection with biochemical materials. In the method described by Werch[3] for the determination of acetone in blood, milk, etc., Conway's procedure is simplified and shortened. In contrast with the original procedure, in which a reaction goes to completion and the end product is titrated, in this, which may be designated as a kinetic diffusion method, the time for the reaction to reach a definite stage is measured with a stop watch.

In this laboratory the method has been found useful in both detection and quantitative determination of a variety of volatile substances.[4] Because of the simplicity of equipment and small space required, the method seemed promising for both the quantitative and qualitative analysis courses in the detection and determination of the anions, as well as for control methods.

The Conway unit is a simple glass diffusion dish 67 mm. in diameter, having two concentric compartments, the outer wall having a ground edge to form a seal with the cover. Either liquid reagents or spot tests on paper are used. The indicating reagent is placed in the inner compartment, and the sample with reagent to form the volatile product in the outer. The reaction in the inner compartment goes through a series of visible stages. Any well-marked change in color or pattern is selected for comparison, and by timing with a stop watch it is possible to estimate concentrations over a wide range with considerable accuracy. The purpose of the continued investigation was to ascertain the limits of accuracy and to develop details of procedure for those substances for which the method is suited.



Vertical section on line *AB*

Conway Unit with Cover Plate

AMMONIA

Conway had devised a highly precise microdiffusion method for ammonia by the slower and more elaborate procedure. Although ammonia, because of its low density, seemed unpromising for the shorter method, its importance as a key substance in the analysis of a great variety of nitrogen compounds makes it desirable that we should have a reasonably accurate method for ammonia much simpler than those commonly in use.

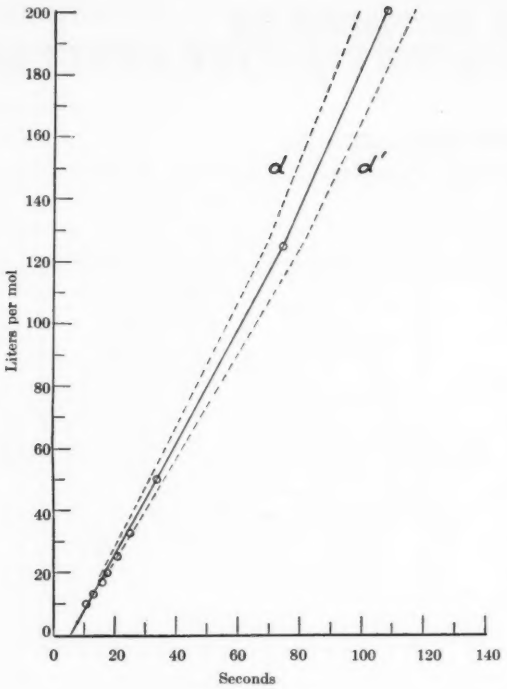
It became apparent at once that ammonia does not form a pattern with Nessler's reagent. This is due largely to the fact that so light a gas must first mix with the air in the apparatus, and then diffuse more or less uniformly to the surface of the reagent. Therefore it was necessary to use a comparison method, for which a series of color standards had to be devised. The light absorption for different concentrations varies both in kind and intensity as well as in the proportion of reflected and transmitted light. Thirty-five series of liquid color standards were prepared before a satisfactory and reproducible one was found. One hundred and sixty-four determinations of ammonia were made in concentrations from 0.001 to 0.100 molar (17 to 1700 parts per million) with these standards. In addition, 34 determinations over the same range of concentrations were made with spot paper in the inner compartment of the dish.

[1] This research project was made possible by a grant from the Carnegie Foundation for the Advancement of Teaching.

[2] CONWAY, E. J., "Micro-Diffusion Analysis and Volumetric Error," Crosby, Lockwood and Son, Ltd., London, 1939.

[3] WERCH, S. C., *J. Lab. Clin. Med.*, 25, 414–20 (1940).

[4] HUGHES, H., Preliminary report on "Use of the Conway Unit in Semi-Micro Analysis," South Carolina Academy of Science, April, 1939.



Reference Chart

The liquid standards for comparison were of two types: a suspension and a solution. The suitability of a particular standard depends upon the range of concentrations to be determined. Also, a standard should be selected for which the time readings are between ten and two hundred seconds. For the larger concentrations, an aqueous suspension of ferric oxide in ferric tartrate solution gave acceptable results. For concentrations of more than a few tenths per cent, better results were obtained by diluting the sample in ratio of 100 : 1. For low concentrations (which includes the range covered by this report), a standard solution was made by mixing equal volumes of 0.01 *M* ferric thiocyanate and 1.0 *M* nickel chloride solutions. The ferric thiocyanate was made by combining exactly equivalent quantities of a ferric salt and ammonium thiocyanate to form the colored $Fe(CN)_6^{---}$ ion.

To make the spot standards strips of C.S. and S. spot paper were cut, and the corners trimmed off. These fit loosely in the inner compartment of the Conway unit. The standard is made by placing one drop of 0.1 *N* ferric chloride solution on the middle of the strip. When the drop is absorbed this is exposed to ammonia fumes to develop a light-brown, nearly circular spot of ferric hydroxide, 10 or 11 mm. in diameter. Excess ammonia is thoroughly evaporated. The fuming may be done conveniently in a Conway unit. Care must be taken not to contaminate any of the materials to be used, since the reagent is sensitive to 1 γ of ammonia in the apparatus. The reagent used is a 4 : 1 dilution of the usual Nessler's solution. When the liquid standard is used in the comparison unit, 2 ml. of reagent is put in the inner compartment of the test unit. When the spot standard is used, one drop of the reagent is placed at the center of a 12 × 34-mm. strip of Whatman No. 1 filter paper in the inner compartment of the test unit. This drop should spread to very nearly the same size as the standard spot on spot paper. The difference in absorbing quality of the papers allows for the difference in surface tension of the solutions used. It is, of course, unnecessary to use an additional unit in the spot procedure. Although more convenient, the spot procedure has so far proved less reliable than the other.

The alkaline reagent used for releasing ammonia, that recommended by Conway,[5] is a saturated solution of potassium metaborate. One milliliter is put in the outer compartment, and the unit tilted gently to distribute the solution. The unit is placed on a piece of white unglazed paper, and the cover plate, a piece of clear glass 75 × 75 mm., is put on, leaving a space at one side just wide enough to admit the tip of a 1.00-mm. pipet for delivery of the unknown. It is convenient to tip the unit slightly by resting one side on the edge of a spare cover plate. As soon as the solution stops flowing from the pipet, the cover plate is slid into position, the unit placed level, and the stop watch started. With practice this can be done in less than one second. Even if several seconds are required, the measurement will be as reliable, provided the operation is carried out every time in precisely the same way. The color standard, either a duplicate unit containing 0.9 ml. of fluid standard in the inner compartment, or the standard ferric hydroxide spot, is placed alongside. When the depth of color in the reaction vessel matches that of the standard, the stop watch is stopped.

The measured time intervals depend upon a number of variables, temperature being one of major importance. The laboratory temperature should not vary by more than one or, at most, two degrees Centigrade during the measurement of a series. Other variables, in addition to concentration of the sample and reagents, are volumes of contents of the two compartments, the thickness of the layer through which light is transmitted, and the type of light source.

For measurements of small volumes, except that of the sample, dropping pipets are sufficiently accurate. These should be made from 7 or 8 mm. tubing, with tip ground even on a rather close grained stone. The other end is slightly flared to hold a 2-ml. rubber bulb. They are calibrated by counting the number of drops of the solution to make 1.0 ml. or 1.0 gram. No attempt should be made to deliver a portion of a drop. For example, in order to deliver 0.9 ml. from an 18-drop pipet, 16 drops are close enough. The student should be cautioned that the same pipet will not deliver the same number of drops per milliliter of different solutions. At least a dozen dropping pipets should be at hand. Several types of illumination have

[5] CONWAY, E. J., *loc. cit.*

been tried, the best by far being fluorescent lamps either just over the work table or in the regular ceiling installation.

PLOTTING RESULTS

Results are determined graphically by interpolation on a reference chart. The relation between dilution (reciprocal of molar concentration) and time for the reaction to reach any selected stage is nearly, but not strictly, linear. A straight-line graph is satisfactory if the range of concentrations is divided into two parts; the first from 0.100 to 0.005 molar, the second from 0.005 to 0.001 molar, and each of these be represented by a straight line. The slopes of these lines differ by a small angle.

To make the reference chart, use two sheets of the commonly available letter-size graph paper divided into 24 vertical and 18 horizontal squares with sides subdivided by fifths. On one, let each division correspond to 10 units. Number the ordinates 0 to 240 units of dilution (liters per mol), and the abscissas 0 to 180 seconds. On the other sheet a smaller scale is used. Number the vertical divisions from 0 to 1200, each division corresponding to 50 units of dilution. The abscissas will have a range of 450 seconds, each division being 25 seconds. Do not number these until the known points have been fixed.

Make a solution of 0.100 *M* NH_4Cl, and dilutions of this of 0.005 and 0.001 *M* concentration. Label these, respectively, *M*/10, *M*/200, and *M*/1000. Make four determinations of each, and plot the average values on the chart. The *M*/200 point will be the upper one on the first sheet, and the lower one on the second. For the high dilution chart, select for the *M*/200 value, a point near the left of the sheet, and number the abscissas accordingly. These probably will start at 100 and end at 550 on the right. It is suggested that for a laboratory exercise, nitrogen samples containing not less than 0.007 per cent NH_3 (0.004 *N*) be assigned for analysis. This will eliminate preparation of the second (high dilution) chart, and time readings of more than three minutes. If determinations of dilutions between *M*/100 and *M*/200 (0.017 and 0.009 per cent NH_3) are to be made, somewhat better accuracy will be had by fixing also the *M*/125 point on the reference graph, since the slope changes appreciably in this region. A portion of such a chart is shown in the figure. The broken lines *d* and *d'* indicate the reliability of the timing with a deviation of ±6 seconds at the *M*/125 point. The centers of the small circles show an actual series of known concentrations.

It will be noted that the graph cuts the time axis at about 5 to 7 seconds. This appears to be quite general and is interpreted as the interval that must elapse between the beginning of the reaction and the arrival of vapor at the surface of the indicator. From this point the rate of change is that of a first-order reaction.

FURTHER DETERMINATIONS

Roughly quantitative determinations have been made of hypochlorite, chloride, sulfite, carbonate, and cyanide ions, and methyl alcohol and formaldehyde. The procedure for hypochlorite is like that for ammonia. A strip of filter paper in the inner compartment is wet with one drop of a 0.05 *M* solution of potassium iodide buffered at a pH of 5. In the outer compartment is put 1.0 ml. of 18 *N* (1 : 1) sulfuric acid. 1.0 ml. of hypochlorite solution is pipetted in, the cover slid into place, and the dish rotated. With a 100 : 1 dilution of the 5.25 per cent commercial sodium hypochlorite solution, corresponding to 0.007 *N* OCl^-, a uniform brown spot appears in six seconds, and is entirely bleached except for a very pale stain in six minutes. For a 0.003 *N* hypochlorite solution the times are 10 seconds and 10 minutes. The test is made more delicate by adding 2 ml. of 0.2 per cent starch solution to each milliequivalent of potassium iodide used in making the indicator solution.

For chloride, the procedure is similar. The indicator is the buffered starch-potassium iodide solution just described. One drop of this is put on a strip of spot paper in the inner compartment. In the outer compartment is put one ml. each of saturated potassium permanganate and 18 *N* sulfuric acid solution. One ml. of the chloride sample is pipetted into this. A 0.0001 *M* concentration (about 4 p. p. m.) of chloride produces a uniform lilac spot in three minutes. A 0.0002 to 0.0010 *M* solution requires about two minutes; and for a 0.005 *M* one, the time is less than one minute.

Such rough-and-ready methods as these last are not offered for quantitative analysis, but may serve for preliminary estimates. Research in progress leads to the expectation of several kinetic-diffusion techniques at least as accurate as that developed for ammonia.

ERRATA

In the table headed "Analogues of DDT," page 654 in the December, 1950 issue, the compound designated by $R_1 = R_2 = 4CH_3OC_6H_4$ was cited to melt at 109°. The correct melting point should be 89°.

In Table 1, page 27, in the January, 1951 issue, the precipitant for methyl ethyl ketone should be 2,4-dinitrophenylhydrazine and not 3,5-dinitrophenylhydrazine.

AUGUSTE LAURENT—GUIDE AND INSPIRATION OF GERHARDT[1]

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Newcomb College, Tulane University, New Orleans, Louisiana

AUGUSTE LAURENT was one of the founders, probably the most important, of modern organic chemistry. Few chemists, however, even in his native France, have recognized his contributions to the development of chemistry. Whenever his name is mentioned in accounts of the history of organic chemistry it is usually associated with that of Charles Gerhardt, his collaborator, as if Laurent had not won a distinctive place among the chemists of his time, that included such leaders as Berzelius, Liebig, Wohler, Graham, and Dumas, several years before Laurent began to correspond with Gerhardt and ten years before Gerhardt moved to Paris in 1848 to collaborate with him.

The writings of Adolphe Wurtz are partly responsible for this misconception of the importance of Laurent. Wurtz was a great admirer of both Laurent and Gerhardt, and it was the enthusiasm of Wurtz for the new chemistry, called at that time the unitary system, that finally led to its official adoption in France after 1890. In 1862 Wurtz published an *éloge* of Laurent and Gerhardt in which he says: "The great figure of Gerhardt will not be separated from Laurent: their work was collective, their talent complementary, their influence reciprocal.[2] In 1868 he expressed the same idea.[3] Since that time most of the writers dealing with this period have accepted this opinion of Wurtz, and as a result have credited to the collaboration of Laurent and Gerhardt what was in truth the work of one of them, Laurent.

There have been published only two accounts of the life of Laurent based on original sources. Both of these are short. The earliest is the obituary published in the *Journal of the Chemical Society* of London.[4] It is not signed but was probably written by Alexander Williamson. The other is by Édouard Grimaux.[5] The account of Laurent's life which follows is a composite of these two, corrected, and amplified to a small extent, by reference to publications in the journals of the period, and to the letters of Laurent and Gerhardt in Grimaux's comprehensive work on Gerhardt.

Auguste Laurent was born November 14, 1807, at La Folie, a small village near Langres in the province of Haute Marne in northeastern France. His father, a wine merchant, intended him to succeed to the business and insisted that he learn bookkeeping. Laurent had no interest in business; he preferred to investigate the plants, rocks, and marshes in the countryside. He constructed a small mill which became an object of admiration by all who knew anything of the difficulties of such work. Laurent's teachers recognized his talent in science and obtained his father's consent to direct his courses toward preparation for college. In his memoirs on chemistry his predilection for names and terms founded on Greek roots is the result of his training in the classics at this period. One of the reasons that has been offered for the failure of the French chemists of his day to recognize the value of his ideas was the elaborate, though logical, system of nomenclature, originated by Dumas but developed by Laurent, that he used in his papers. Among Laurent's own inventions that have survived are phenyl and anhydride.

With his brother Charles he was sent to the small college at Gray near his home, and in 1826, with the help of a maternal uncle, he entered the School of Mines in Paris as a day student. In 1828 he was sent on a mission to Germany where he visited mines and factories, on which he made careful observations and took notes that he later used in his work on inorganic chemistry. His first laboratory research in chemistry was on the ores of cobalt and arsenic. In his last year at the School of Mines he began the study of theoretical organic chemistry.

Laurent received his diploma as an engineer of mines December 30, 1830, and shortly afterward became Dumas' assistant at the Central School of Arts and Manufactures, a technical college founded in 1828 by Dumas and three others, all of whom were engineers. Working with Dumas, a great master of analysis and laboratory technique, Laurent learned organic analysis and began research. Dumas suggested the topic: a better method for the isolation of naphthalene from coal tar, its purification and analysis (then in doubt), and its reactions with the halogens and nitric acid. His first memoir on naphthalene appeared in 1832.[6] He described the purified naphthalene crystals, confirmed the formula of Faraday, C_5H_2 (C = 6, the atomic weight of carbon advocated by Gay-Lussac), and reported the vigorous reactions of chlorine, bromine, and

[1] Presented before the Division of the History of Chemistry at the 117th Meeting of the American Chemical Society at Philadelphia, Pennsylvania, April 12, 1950.

[2] WURTZ, ADOLPHE, *Le Moniteur Scientifique*, 4, 482 (August 1, 1862).

[3] WURTZ, A., "Dictionnaire de Cfiimie." 1868, xxxvii. WURTZ, A., "A History of Chemical Theory," Translated and edited by Henry Watts, 1869, p. 83.

[4] *J. Chem. Soc.*, 7, 149 (1855).

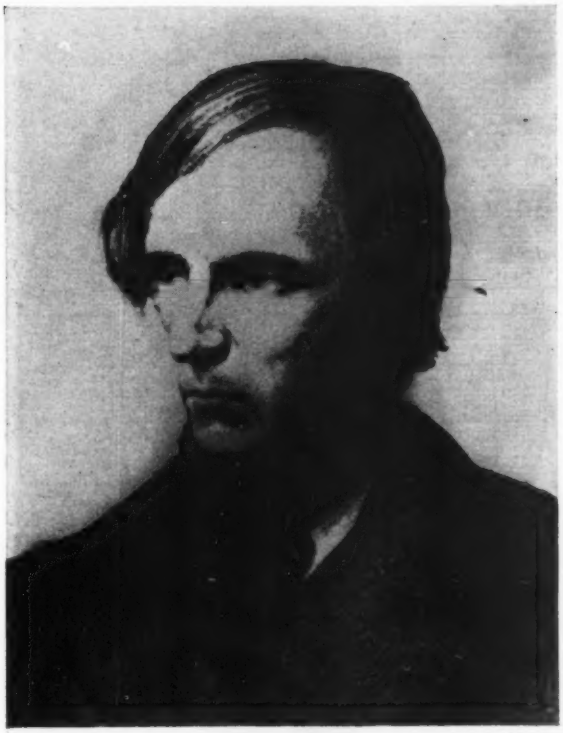
[5] GRIMAUX, É., "Auguste Laurent," *Rev. Sci.*, [4] 6, 161–163 (1896).

[6] *Ann. Chim. et Phys.*, [2] 49, 214 (1832).

nitric acid with the hydrocarbon. The following year the first of his many papers on the chlorination of naphthalene appeared. In this paper are his first speculations on the chlorine substitution and addition products of naphthalene.[7] He had prepared two chlorides: a solid and a liquid. He suggested that the oily chloride is probably analogous to "Dutch liquid" (ethylene chloride) on which he had already begun to work.[8] In the second volume of *Annales de Chimie et de Physique* for 1835 Laurent described and outlined his theory of fundamental and derived radicals.[9]

At the beginning of 1833 he had been appointed by Alexandre Brongniart to direct the testing laboratory at Sèvres. At this time he discovered and published the process for the analysis of silicates by the action of hydrofluoric acid.[10] Analytical work in this porcelain factory was not congenial to him so he resigned, and in 1835 he moved to a garret in Rue St. André des Arts where he fitted up a laboratory and opened a school. His pupils became deeply attached to him and many of them remained his friends as long as he lived. To his dismay he discovered that teaching students laboratory technique took up so much of his time that he had less for research in organic chemistry than he had had at Sèvres. He dismissed the students and spent all his time on research. When his money was gone he reopened the school and the students returned in a body, paying him regularly eighty francs a month. Again he dismissed the students. Once more he found himself without the funds to purchase the materials he needed, so he accepted the offer of a perfumer to work in his shop, where Laurent distilled essences and tested their purity. According to the account in the *Journal of the Chemical Society* he was so absorbed in his own researches carried out in this shop in Rue Bourg-l'Abbé, that he never demanded a regular salary and only occasionally asked for a five franc piece. When Laurent left the shop his employer settled his account and presented him with 10,000 francs! Soon afterward he lost this money in an industrial venture and this sobering experience convinced him that it would be wise for him to devote his life to pure science.

In this shop Laurent worked happily and effectively for almost two years; here he carried out the first of his famous experimental researches in organic chemistry. During this period he developed his ideas on substitution reactions and worked out a classification of organic compounds based on the fundamental hydrocarbon radical of which they were derivatives, a radical composed always of the same number of carbon atoms. His published memoirs brought him into conflict, first with Dumas over the theory of substitution, later with Liebig and Berzelius. Thus, before he was thirty he began the struggle for the recognition of his ideas, a struggle that would continue without interruption until his death in 1853 at the age of forty-six. This struggle would end in the overthrow of the dualistic theory of the composition of organic compounds, which had been set up by Berzelius, based on Berzelius' electrochemical theory of the constitution of inorganic oxides, salts, acids, and bases.



Courtesy of the Edgar F. Smith Collection, University of Pennsylvania, Philadelphia, Pa.

Auguste Laurent

Laurent presented and defended his theory of fundamental and derived radicals (later called by Laurent the nucleus theory) as a thesis for the degree of Doctor of Science, December 20, 1837, before a committee of the Academy of Sciences composed of Dumas, Dulong, Beudant, and Despretz. One can be sure that of those who heard him only his former teacher, Dumas, understood the import of his assumptions. His thesis presented a theory of the constitution of organic compounds supported by experimental evidence based on his own work on the reactions of chlorine, bromine, and nitric acid on organic compounds, mostly hydrocarbons.[11] Laurent's thesis was the first organized attack on the dualistic theory of Berzelius.

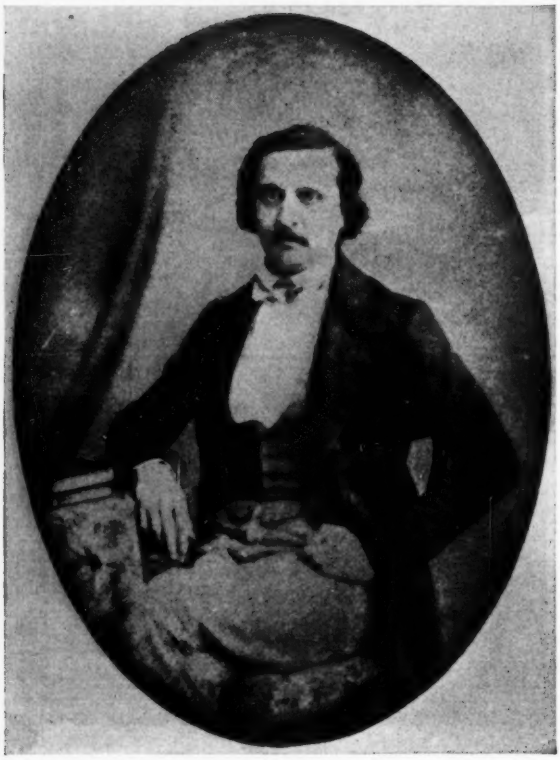
[7] *ibid.*, [2], **52**, 275 (1833).

[8] LAURENT, A., "Méthode de Chimie," **1854**, 227; W. ODLING, "Chemical Method," Trans. of "Méthode de Chimie," **1855**, 187.

[9] *Ann. Chim. Phys.*, [2], **59**, 376 (1835); É. GRIMAUX, *loc. cit.*, 164.

[10] LAURENT, A., "Nouveau procédé pour analyses les silicates alcalines," *Ann. Chim. Phys.*, [2] **58**, 428 (1835).

[11] His thesis was a summary of papers already published. He illustrated his theory by likening the fundamental radical to a geometrical figure. A fundamental radical, as C^8H^{12}, might be thought of as a 4-faced prism with eight carbon atoms occupying the eight corners and with twelve hydrogen atoms attached to the middle points of the twelve edges. A. LAURENT, *loc. cit.*, p. 237; A. LADENBURG, "A History of Chemistry," 2nd ed., trans. by Leonard Dobbin, 1900, p. 144; E. GRIMAUX, *loc. cit.*, p. 164.



Courtesy of the Edgar F. Smith Collection, University of Pennsylvania, Philadelphia, Pa.

Charles Gerhardt

Early in 1838 Laurent accepted a position in a porcelain factory in Luxembourg. His stay there was short. Not long after his return to Paris he was named professor of chemistry in the Faculty of the University of Bordeaux. In May, 1839, he married the daughter of a judge of the Superior Court in Luxembourg. Grimaux in his biography says that the widow of Laurent told him (in 1896) that Laurent's vacations from the university were always spent at the home of his wife's parents despite the long journey from Bordeaux.

At Bordeaux he found no laboratory, so that during the first year there, while he was fitting up a laboratory from his own small income, he spent much of his time with his associates on the faculty, especially with Lebesgue, a distinguished mathematician, and with the dean, Count de Collegno, professor of geology. The amount of his experimental work in this poorly equipped laboratory is truly amazing, especially when it is remembered that he worked alone. His investigations center around three projects: (1) the study of the components of coal tar, which led in 1841 to the isolation of phenol and the preparation of its derivatives one of which, called by him nitrophénisique acid, was proved to be identical with picric acid, already known; (2) the study of indigo, from which he prepared isatin and its derivatives; (3) the completion of the work on the derivatives of naphthalene, which included the correction of some of the formulas and relationships he had proposed in earlier papers, for example that of phthalic acid.

Besides these beautiful researches he found time for an investigation of pine tar, from which he isolated pimaric acid, to say nothing of his occasional papers on some of the fatty acids, on complex salts of the metals, and on silicates.

In all this work Laurent was collecting facts to support the great idea conceived sometime in 1834: the organization of organic compounds and their reactions on a logical and understandable foundation. On February 15, 1845, he wrote to Gerhardt: "Your classification is poor; (Laurent is criticizing volume one of Gerhardt's "Précis," his first textbook on organic chemistry published in July, 1844).... Do you ever develop anything from your classification? No, nothing, absolutely nothing because there is no idea in it. A classification should offer a series of relationships. It is my opinion that without a dominating idea it is impossible to do anything."[12]

In 1838 the attacks on Laurent's so-called theory of substitution (opposition to the electrochemical theory) began in earnest. To Laurent this was not primarily a theory of substitution and therefore was not in any sense at variance with Dumas' law of substitution. It was a theory of the constitution of organic compounds (what Dumas in 1840 called the type theory) the validity of which was demonstrated by substitution and oxidation reactions. Liebig in the first number of the *Annalen* for 1838 devoted thirty-one pages to an attack on Laurent and his speculations.[13] Compared with many of Liebig's polemics against those who did not agree with him, his remarks on Laurent are mild. Liebig most certainly does not refute Laurent's suppositions; most of the paper is taken up with a criticism of his analyses made in 1835, when Laurent's laboratory facilities were inadequate. By the time this paper was written he had reported the correction of most of these analyses. In 1835 Laurent had published a paper on the benzoyl radical[14] in which he describes benzil prepared by passing a current of chlorine into fused benzoin. He treated benzil with strong potash and obtained an acid, which he did not analyze but which according to this theory he assumed to be benzoic acid (the acid was benzilic acid; this is the benzilic acid rearrangement). Liebig repeated the work and three years later reminded Laurent that because of his speculations he failed to discover a new acid. This paper of Liebig's, which begins with his classic definition of a radical, is often quoted to the detriment of Laurent.[15] Liebig's attack was followed by a more serious one by

[12] GRIMAUX, É., "Charles Gerhardt, sa vie, son oeuvre, sa correspondance," 1900, p. 344.

[13] "Ueber Laurent's Theorie der Organischen Verbindungen," *Ann.*, 25, 1 (1838).

[14] *Ann. Chim. Phys.*, [2] 59, 397 (1835).

[15] LADENBURG, A., *loc. cit.*, pp. 149, 163; E. VON MEYER, "History of Chemistry," 3rd ed., trans. by George McGowan, 1906, p. 290.

Berzelius,[16] who remarks on Laurent's rare talent for research, "the value of which is considerably diminished by his bizarre theories." Berzelius, however, had mistakenly assumed that the idea that electronegative chlorine could replace electropositive hydrogen without essentially altering the nature of the substance was that of the French school, and he therefore directed the attack against Dumas. Dumas answered Berzelius.[17] He reminded Berzelius that his contribution was the law of substitutions, not a theory. He implied also that the work of Laurent was not to be relied upon. Laurent defended his position. He would assume all responsibility for the ideas opposed to the electrochemical theory as it applies to the constitution of organic compounds.[18]

Late in the summer of 1838 Dumas prepared trichloracetic acid. In April, 1839, the detailed paper on its reactions, its salts, and esters appeared. At the end of this paper Dumas announced a theory of types.[19] In February, 1840, Dumas presented to the Academy his now famous paper on the type theory.[20] Laurent's claim to the priority of the theory of substitution (opposition to the electrochemical theory) and of types or derived radicals appeared in the March 9 issue of the *Comptes rendus*. This is the beginning of the contest between Dumas and Laurent that continued several years.[21]

Berzelius, whose dualistic theory had been given its death blow by the theory of types, was the first to recognize the priority of Laurent. Liebig's recognition followed. In the summer of 1844 Laurent visited Giessen, where he gave "by request of the students in the laboratory an extempore discourse on his theories. .... Liebig offered him at that time an entire number of his *Annalen* for the publication of a review of his labors and of the ideas which had guided him in his researches; and three of the students offered to translate the work into English, German, and Italian."[22] In 1845 Liebig's student, A. W. Hofmann, in his paper on the chloroanilines discussed at some length Laurent's ideas, pointing out that his own work offered additional proof of their validity.[23]

It was during this period that the correspondence between Laurent and Gerhardt began, probably in the winter of 1843–44, as the first letter that has been preserved, one from Laurent to Gerhardt, dated July 4, 1844, begins, "Mon cher collègue." Gerhardt in 1842 had written an article published in Dr. Quesneville's *Revue Scientifique et Industrielle* claiming the priority of the discovery of Laurent's "draconic" acid for his friend Cahours. Gerhardt pointed out that draconic acid was identical with Cahour's anisic acid reported earlier. In November, 1842, Laurent, convinced of the identity of the two acids and also of the younger chemist's priority in the matter of publication, graciously conceded Cahour's priority. Dr. Quesneville, who realized that Laurent and Gerhardt would have many interests in common, since both were opposed to the dualistic theory of Berzelius, arranged for a meeting of these two chemists at his home in Paris in the summer of 1843.

Laurent's letters to Gerhardt written during the winter of 1844–45 show signs of his growing discontent with his life at Bordeaux. Gerhardt, also dissatisfied with his isolation at Montpellier,[24] said nothing in his replies to calm Laurent's now rebellious spirit. His intellectual activity at Bordeaux had been intense and by 1845 he must have been exhausted. At long last his brilliant experimental work had been recognized in Paris. April 29, 1844, he was named *chevalier de la Legion d'honneur;* on August 11, 1845, he was elected a corresponding member of the Academy, replacing Faraday who was promoted to an associate. For some time he had entertained a hope of obtaining a position at the Mint. In the fall of 1845 he asked for a leave of absence, and with his wife and son left Bordeaux. He arrived in Paris with little money, as he had received only one-half of his salary, and with no immediate prospect of a position. For the next two and a half years he divided his time between the instruction of students and researches of little consequence, mainly inorganic, carried out in the laboratories of his friends. His spirits were low, as is shown by his letters to Gerhardt. His friends were urging him to break off relations with Gerhardt, whose dictatorial manner and harsh denunciations of the work of other chemists had made him both feared and disliked. Liebig wrote to Laurent on January 30, 1846: "...If you associate yourself with him [Gerhardt], it is you who will lose because he has nothing to lose. Read with attention my article ("Herr Gerhardt und die organische Chemie," *Ann.*, **57**, 93, 1846) and tell me whether this man has the truth in his soul?.... I believe you to be a man of perfect loyalty and honesty who...has linked his destiny with that of a man without character and without morality."[25]

On March 13, 1848, Laurent wrote to Gerhardt that he had been nominated assayer at the Mint to succeed Péligot. This position gave him no laboratory for his own work but the income enabled him to equip one. Thus, in "a corner of the Hôtel de la Monnaie, in a kind

[16] *Compt. rend.*, **6**, 633 (1838); *Ann. Chim. Phys.*, [2], **67**, 312 (1838); E. HJELT, "Geschichte der organischen Chemie," **1916**, p. 103.

[17] *Compt. rend.*, **6**, 647, 699 (1838); C. SCHORLEMMER, "The Rise and Development of Organic Chemistry," **1894**, p. 35.

[18] *Ann. Chim. Phys.*, [2], **72**, 403 (1839).

[19] *Compt. rend.*, **8**, 609 (1839); "Premier mémoire sur les types Chimiques," *Ann. Chim. Phys.*, [2], **73**, 73 (1840); *Ann.*, **35**, 129 (1840).

[20] "Memoire sur la loi des substitutions et la theorie des types," *Compt. rend.*, **10**, 149 (1840). Dumas went too far in his enthusiasm over this idea and Wöhler's letter in the *Annalen* [**33**, 308 (1840)], signed S. C. H. Windler, pointed this out. For the English translation of this letter see H. B. FRIEDMAN, "The theory of types—A satirical sketch," J. CHEM. EDUC., **7**, 635 (1930).

[21] GRIMAUX, É., *Rev. Sci.*, [4] **6**, 168 (1896).

[22] NICKLÈS, J., "Auguste Laurent," *Am. J. Sci.*, [2], **16**, 103 (1853).

[23] *Ann.*, **53**, 3 (1845).

[24] OSTWALD, W., "Grosse Männer," **1909**, 229, 250.

[25] GRIMAUX, É., "Charles Gerhardt," **1900**, p. 125.

of cellar, dark, damp, and unhealthy."[26] Laurent carried out his last researches in organic chemistry[27] and here he contracted tuberculosis. Now that Laurent had a laboratory where the two friends could work together, Gerhardt decided to join him; so, also without the prospect of a position, Gerhardt left Montpellier on March 17, 1848. For two and a half years these two dissenters collaborated in most of their papers relating to the theory of organic chemistry. There is not the slightest doubt in the mind of this author that without this daily association with Laurent, Gerhardt could not have written his great treatise on organic chemistry.[28] His book would have been just another in the field, and Gerhardt's name would be as little known as that of a host of able men working in Paris at this same time.

[26] *J. Chem. Soc.*, **7**, 154 (1855).

[27] In 1850 he prepared the acid which bears his name. *Compt. rend.*, **31**, 537 (1850).

[28] GERHARDT, C., "Traité de Chimie Organique," Vol. 1, **1853**; Vols. 2 and 3, **1854**; Vol. 4, **1856**.

Courtesy of Professor Colin M. Mackall, The George Washington University, Washington, D. C.

Statue of Auguste Laurent

This bronze monument, designed by Péchiné, was erected in 1903 in the Place de l'Hôtel de Ville in Langres. The author has received word from l'Abbé F. Rabin, adjointau Maire de Langres, that it was removed by the Germans in World War II.

The influence of Laurent's laboratory in the rapid development of the new organic chemistry has never been appreciated. The author (Williamson?) of the obituary in the *Journal of the Chemical Society* has given an excellent account of the activity there and also of the manner of work of Laurent: "His laboratory was the rendezvous of a great number of scientific men; there was no lack of news there; and Laurent had every day some new result to announce, or some new idea to develop. Raw materials were also sent to him from all sides for examination.... Laurent possessed a degree of analytical tact never before known; his researches on naphthaline, indigo, bitter-almond oil, etc., remain as monuments to a genius for investigation which, unfortunately, will not soon be equalled.... [He] used a small number of reagents...: chlorine, nitric acid, ammonia, sulfuric acid, potash.... Water, alcohol, ether, and the goniometer served him for the recognition of his products. He was the first to employ the goniometer as a reagent, and no one knew better how to manage it."

In November, 1846, Laurent published his last important paper on theoretical chemistry.[29] In this paper he develops at length the difference between an atom and a molecule and explains the basis for the new notation used in the formulas of the organic compounds of nitrogen given in tables. A molecule is defined; the hypothesis of Avogadro (always referred to by Laurent as Ampère's hypothesis) is discussed; the atom is distinguished from the molecule and from the equivalent.[30] In the last part of the paper (pages 293–298) Laurent outlines the water-type theory that was to be used in 1850 by Williamson, and by Chancel in the synthesis of the ethers, and by Gerhardt in 1852 in the synthesis of the acid anhydrides. The great importance of this idea, however, was pointed out first by T. Sterry Hunt.[31] In later papers Hunt extended Laurent's idea and on the basis of these papers claimed priority to the water-type theory in 1861.[32] There is much justice in Hunt's claim, but that is another story.

Among those who had followed the work of Laurent none was more conscious of its value than Leopold Gmelin. In 1847 word reached Paris that Gmelin in the first volume on organic chemistry (published in 1848) of the 4th edition of the "Handbook" had adopted Laurent's classification of organic compounds. At the anniversary meeting of the London Chemical Society of March 30, 1850, Laurent was elected a foreign member, along with Brongniart, Chevreul, Gay-Lussac, Gmelin, Kopp, Mitscherlich, Pelouze, Regnault, Rose, Thénard, and Wöhler.[33] Laurent's work had been

[29] "Recherches sur les combinaisons azotées," *Ann. Chim. Phys.*, [3], **18**, 266 (1846).

[30] Laurent's adoption of Gerhardt's so-called equivalents, and certain other aspects of his work, will be discussed in an article in *Chymia*, **4** (1951).

[31] *Am. J. Sci.*, [2] **6**, 173 (1848).

[32] HUNT, T. S., "On the Theory of Types," *Am. J. Sci.*, [2] **31**, 256 (1861).

[33] *J. Chem. Soc.*, **3**, 97 (1850).

recognized in foreign countries but his native France had yet to offer him a laboratory.

Late in 1850 Pelouze resigned the chair of chemistry in the Collège de France. Gerhardt applied but was told that he had no chance for the place. This left as candidates Balard and Laurent. Jean Baptiste Biot, who for many years had been professor of physics in this school, appeared in person before the faculty to support Laurent. The vote in the faculty was thirteen to nine in favor of Laurent. The final decision, however, rested with the Academy. Biot wrote a letter to the committee of the Academy pointing out that Laurent with no laboratory was doing important research, whereas Balard with two fine laboratories was doing little in either of them. Biot's efforts were in vain. The final vote in the Academy of twenty-five to eleven gave the chair to Balard.[34]

Laurent's last hope of a well-equipped laboratory was gone. Shortly after he received the news he collapsed. His physicians ordered him to give up all laboratory work. His laboratory was closed. His part—the major part—of the reform[35] movement was over. After Laurent's laboratory was closed, Gerhardt organized his School of Practical Chemistry. Kekulé attended Gerhardt's conferences from May, 1851, until April, 1852, but Kekulé never saw Laurent.[36] The friends of Laurent, especially Biot, Nicklès, and Balard urged him to organize his ideas and theories in the form of a systematic work. At this, his last contribution to the advancement of the science to which he had devoted his life, he worked as long as he could hold a pen. The manuscript of "Méthode de Chimie,"[37] published in 1854, after his death, was recently presented to the French Academy for its Archives.[38]

In January, 1852, Laurent was granted a three-months' leave; he spent part of the summer of 1852 in the country, and on his return in the fall he was sufficiently improved to present three papers to the Academy, on September 20, November 2, and November 22. These are his last published memoirs. He died April 15, 1853. Gerhardt on May 16, 1853, wrote to Chancel, then at Montpellier, that even though he had been prepared for this sad event for a long while, it had affected him deeply. Then he says: "I know nothing about it. I learned of it only ten hours before the burial, as you did, through a simple announcement.... The burial was very sad, twenty or thirty persons at the most. Not a word at the grave!" Ostwald writing of this in his life of Gerhardt says: "Thus ends one of the blackest pages in the history of French science."[39]

The personality of Laurent was described in the first two obituaries published after his death; in the one by Nicklès in the *American Journal of Science* and in the obituary in the *Journal of the Chemical Society*. The remarks in the French journals are copied from the latter. The following is quoted from this source also. "Laurent was of a very kind and obliging disposition, extremely indulgent to others, and his friendship was capable of standing the severest tests. To a just sentiment of his own dignity, he united great firmness of his convictions; his mind revolted from injustice, and he was always ready to acknowledge his errors and even go to the side of his adversary, as shown especially in his discussions with Gerhardt in 1844 [1843] on the constitution of draconic acid, etc. [This is the only mention of Gerhardt in the obituary.] He was one of those persons of whom it may be said that they improve upon acquaintance. Cold and reserved at first, he soon became confiding and expansive, and removed any unfavourable opinion of him formed from hearsay. He may have been envied, but he had no enemies; he sometimes met with ingratitude, even from those on whom he had conferred the greatest benefits:—such ingratitude, in fact, embittered his last moments."

What is the implication in this last sentence? To whose ingratitude is the author referring? He is undoubtedly referring to that of Gerhardt. It seems to the author of this paper that this conclusion is inescapable. Here is some of the evidence: (1) Gerhardt's letter to Chancel; (2) the omission of Gerhardt's name as his friend in the obituary in the *Journal of the Chemical Society;* (3) the letter of Williamson to Gerhardt written April 28, 1853, asking for details of Laurent's life and Gerhardt's reply of May 7, 1853[40]; (4) the omission of Gerhardt's name as his friend in the account by Nicklès and the remarks about Laurent's character; (5) the obituary of Gerhardt by Nicklès[41] in which Laurent's name is mentioned several times but not as Gerhardt's friend; (6) the silence of the English chemists for the next twenty-five years about what the German chemists called "Gerhardt's system and his type theory."

What caused the parting of the ways of Laurent and Gerhardt the last few months of Laurent's life and turned Laurent's friends and admirers against Gerhardt

[34] GRIMAUX, É., *Rev. Sci.* [4] **6**, 162 (1896).

[35] For another and different view of this reform movement see the article by Maurice Daumas in *Chymia*, **1**, 155 (1948).

[36] ANSCHÜTZ, R., "August Kekulé," **1929**, p. 28.

[37] Translated by William Odling as "Chemical Method" and published in 1855 by the Cavendish Society.

[38] The presentation was made by Marc Tiffeneau in the name of Madame Hermann Laurent, widow of the only son of Auguste Laurent. Tiffeneau's remarks are worth quoting. He said: "This work, which marks an epoch in the history of chemistry, contains all the principles of the work of reformation accomplished by Laurent and Gerhardt." *Compt. rend.*, **209**, 585 (1939).

[39] OSTWALD, W., *loc. cit.*, p. 247.

[40] GRIMAUX, É., "Charles Gerhardt," **1900**, p. 242. Williamson writes, "You, certainly, more than any other person know the details of his life" (trans. from the French of Grimaux). Gerhardt in his reply speaks of Laurent's manuscript of "Méthode de Chimie," and adds: "I know only about its content, Laurent having told me some time ago (dans le temps) of certain parts ... it is full of new and arresting views. I await its publication with impatience." This letter was written after April 27, the date of Nicklès' communication on Laurent to the editor of the *American Journal of Science*, in which Nicklès says that he has the manuscript in his hands and that the printing of it will shortly follow.

[41] *Am. J. Sci.*, **23**, 102 (1856).

after Laurent's death? No definite answer can now be given to this question. One can only make a guess: the appropriation of the water-type theory by Gerhardt in 1852 after his discovery of the acid anhydrides.[42]

What were these "greatest benefits" that Laurent had conferred upon Gerhardt? Before Gerhardt moved to Paris in March, 1848, to work in Laurent's laboratory, Laurent in long letters criticized Gerhardt's classification of organic compounds in the "Précis" and also in his papers; he pointed out to Gerhardt his mistake in disregarding entirely the theory of radicals so that Gerhardt developed his theory of residues; he explained to him in great detail that the terms, "atoms, equivalents, and volumes" are not synonymous![43] (So stated in the "Précis.") Gerhardt in February, 1848, published a small but important book: "Introduction to the Study of Chemistry by the Unitary System." It is dedicated to Laurent. It could not have been written by Gerhardt unless he had had Laurent's instruction, for the ideas are primarily those of Laurent. Gerhardt had an excellent memory, and great talent for the organization and generalization of facts; his chief interest was in writing. His great treatise is written in the clear, easily followed, expositional style so characteristic of all his work and this accounts in large measure for its popularity. But he possessed little or no originality; he had almost no talent for and no real interest in experimental research, and he did not grasp new ideas readily. His confusion about principles stimulated Laurent's thinking, and there is no question that Laurent's association with Gerhardt helped Laurent to clarify and express his own ideas. Laurent could never have written a treatise that would have won over the German chemists of the time to the new organic chemistry. He was much too philosophic, too interested in speculation, and too devoted to experimentation for this kind of work and he knew it. Gerhardt with his aggressive, dictatorial manner promoted Laurent's ideas, and tried in so doing to promote his own interests, but because of his manner and his positive assertions he built up resistance, at least in Paris, to both of them. After Laurent's death Gerhardt did no experimental work of any importance. The master who had guided him and inspired him to interpret the facts of chemistry was no longer there to direct the channels of his thinking. But he finished his treatise.

Had Gerhardt in the preface to the first volume of this great work acknowledged his debt to Laurent; had he written an introduction to "Generalities," the last and by far the most important section of volume four of the "Traité," an introduction in which credit was given where credit was due, to Hofmann, Frankland, Williamson, Hunt, and, above all, to Laurent for their contributions to the theory of types; had he pointed out that Laurent was the first to clarify the terms equivalent, atom, molecule, the first to apply Ampère's hypothesis to the determination of the molecular weights of volatile organic compounds—the history of organic chemistry as it has been written would be different.

In the preface to volume one Gerhardt attributed the first type theory (1840) to Dumas. This from a man who had earned part of his income by writing for Dr. Quesneville's *Revue Scientifique et Industrielle*, in which Laurent's papers claiming his priority to this theory had appeared! The preface is dated June, 1853. Was it written before this and did Laurent learn of his so-called friend's perfidy before the book went to press? Perhaps. Kekulé is said to have read volume one in manuscript in 1852. Laurent's friends, and most certainly Dumas himself, recognized Gerhardt's gesture to Dumas for what it was—a deliberate misstatement to further the interests of a man whose over-powering ambition had motivated his entire life. What Gerhardt desired most was a position in Paris. What Dumas offered him, and what he accepted, were two professorships at Strassburg, where once again he found himself isolated from the center of activity in chemistry—Paris. Here he died August 19, 1856.

When Gerhardt wrote the "Generalities" he had Laurent's "Méthode de Chimie" in front of him, for he refers to it on page 599; but except for this reference to "Laurent et moi," Laurent's name is mentioned only in the discussion of certain experimental work. Gerhardt writes of "my classification," "my distinction between equivalents, atoms, and molecules," "my idea of types." He assumes the credit for all of them—hydrogen, hydrochloric acid, ammonia, water—not one of which originated with him.

His four-volume treatise was translated into German immediately following the appearance of the volumes in France. Cannizzaro and the German chemists at the Congress at Karlsruhe spoke only of Gerhardt's system. After 1862, due to the efforts of Wurtz, some of them added the name of Laurent.

ACKNOWLEDGMENT

The author wishes to thank the staff of the Stanford University Libraries and the staff of the Chemists Club Library in New York for their courtesies to her. Especially does the author thank Robert F. Sutton, Curator of the Edgar F. Smith Collection at the University of Pennsylvania, for locating information about Laurent and his publications. Part of the expenses of gathering the material for this paper was met by a Carnegie grant-in-aid given the author by the University Council on Research of Tulane University.

[42] For a discussion of this the reader is referred to the account given by Grimaux in the life of Gerhardt, and to Ostwald's comments on Grimaux's excuses for Gerhardt's behavior. The papers of Williamson, Chancel, and Gerhardt are enlightening, especially those in the *Annalen*.

[43] GRIMAUX, É., *loc. cit.*, p. 531.

DESK AND POWER SUPPLY FOR THE BECKMAN SPECTROPHOTOMETER[1]

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Iowa State College, Ames, Iowa

THE following description of accessory equipment for the Beckman Model DU spectrophotometer is the result of considerable effort directed toward devising an arrangement which would permit nearly constant use of this instrument with a minimum of maintenance. Since the Model DU is used so extensively, it was felt that publication of this report would be of value to other users of this instrument. The desks and power supply described herein have been in daily use for over a year and have given excellent service.

In these laboratories two instruments were available, one being reserved for use with the tungsten lamp and the other being reserved for use with the hydrogen discharge light source. This arrangement eliminates changing lamp housings and the subsequent refocusing of the light beam. The power supply described below is suitable for use with both the tungsten and the hydrogen discharge lamps.

DESIGN OF THE DESK

One of the few disadvantages of the Beckman instrument is that the position of the dials and controls on the horizontal top makes continuous work at this instrument extremely tiring. To overcome this difficulty, two desks were designed and constructed. The general design is similar to a standard double pedestal office desk, the essential feature being that there is no drawer or other obstruction on the under side of the top in the center section. This permits placing of the instrument at a lower level with respect to the operator, *i. e.*, the instrument is very nearly "sitting in the operator's lap." The desk top is cut out at the center section in such a way that it is possible to get close to the instrument. These innovations permit the analyst to sit erect in a chair and read the instrument by simply bending his head downward.

Figure 1 shows the desks and location of the power supplies. The left pedestal of each desk contains the storage batteries, charger and other electrical components of the circuit. The right pedestal of the desk in the background has a deep drawer in the position corresponding to the hydrogen discharge lamp power supply which is visible in the foreground. The drawers visible in Figure 1 do not extend to the rear panel of the desk, thereby leaving space to bring the lamp leads through the desk top. All leads to the instruments are brought through small holes which were made in the desk tops.

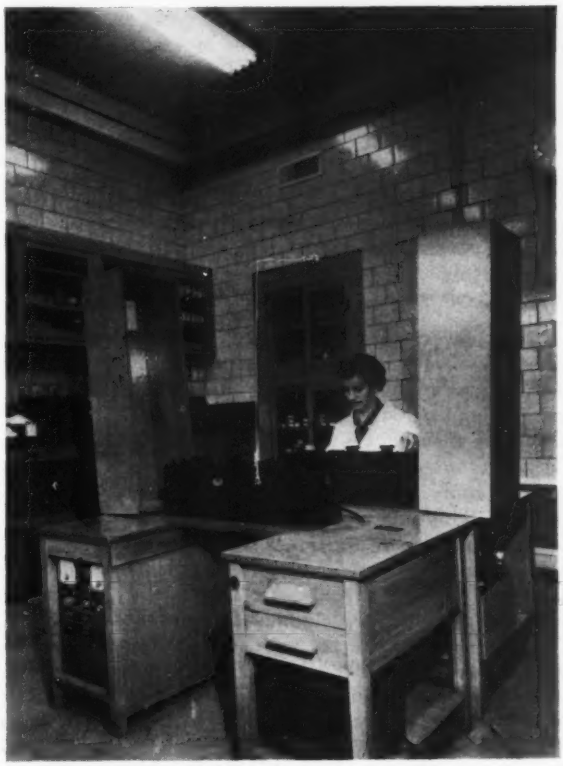


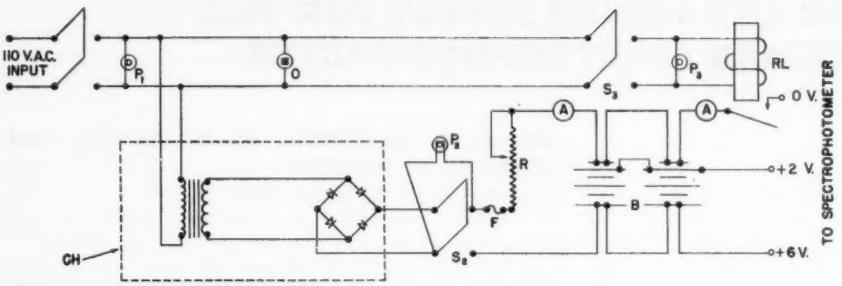
Figure 1. View of Spectrophotometer Desks

The desks were constructed of oak and plywood. The over-all dimensions are: 29 in. wide, 55 in. long, and 26 in. high. The dimensions of the top are such that the flame photometer attachment may be installed. Sufficient space is available, for a notebook in which to record data, at either side of the operator.

The length of the plywood instrument cover is such that it can be closed when the large cell compartment accessory is in position for use. This cover lacks many aesthetic qualities, but was necessitated by cost considerations.

The possibility of sloping the instrument toward the operator by means of wedges was considered, but not put into use because it increases the hazard of solution spillage from the cuvettes.

[1] Contribution No. 135 from the Institute for Atomic Research, Ames, Iowa. Work was performed in the Ames Laboratory of the A. E. C.



$S_{1,2,3}$ — DPST TOGGLE SWITCHES
$P_{1,3}$ — 110 V., 6 WATT CANDELABRA BASE PILOT LAMP
P_2 — 6 V., 1.5 WATT MINIATURE BASE PILOT LAMP
A — 0–10 AMMETER
R — 3Ω 25 WATT OHMITE RHEOSTAT
RL — 15 AMP., 110 VOLT MERCURY PLUNGER, H–B INSTRUMENT CO.
CH — MALLORY 6AC6 DRY PLATE BATTERY CHARGER
O — NON-POLARIZED RECEPTACLE FOR ULTRAVIOLET POWER SOURCE
B — 2-120 AMPERE HOUR STORAGE BATTERIES
F — 10 AMP. 3 AG FUSE

Figure 2. Schematic Diagram and Parts List for Spectrophotometer Power Supply

DESIGN OF THE POWER SUPPLY

The power supply described below is simply an adaptation of well-known concepts of electricity. The actual design is probably quite similar to commercially available power supplies.

Figure 2 shows the circuit diagram together with a list of its integral parts. The approximate cost of the power supply, less the two storage batteries and charger, is $30. This sum is very small when compared to the original investment for the Beckman instrument.

A Sorenson voltage regulator is in use in these laboratories to provide a constant 115-volt a.-c. source for various instruments including the spectrophotometers. Tests have indicated that voltage regulation is unnecessary when operating the charger in conjunction with the tungsten lamp. Usually it is possible to charge the storage batteries when using the hydrogen discharge lamp; but since the current drain is very small, it is probably best to carry out the charging operation at a time when the instrument is not in use. A consideration of local power conditions must determine the necessity of voltage regulation.

It can be seen from Figure 2 that the three switches turn off all power to the instrument except, of course, the $7\frac{1}{2}$-volt batteries located in the bottom of the instrument case. These switches, together with their pilot lights, help to eliminate the chance that the instrument and lamps will be left on unnecessarily.

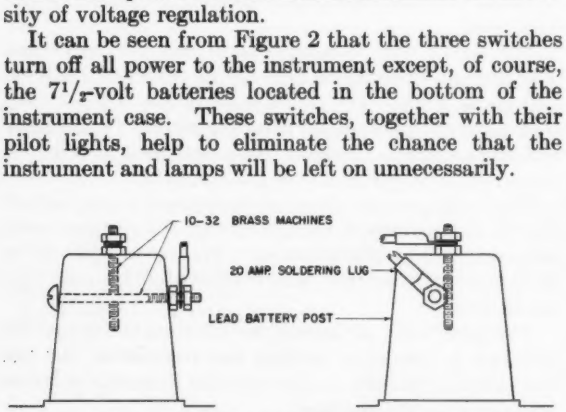


Figure 3. Detailed Views of Battery Post Connections

Figure 3 shows the actual connections which were made to the storage batteries. Each battery lead was attached to the proper post by a separate screw. The use of two metal screws on each terminal is a distinct advantage as shown by an oscilloscope connected across the output leads. When the battery post connections were made as indicated in Figures 2 and 3, no a.-c. ripple could be detected in the output. For spectrophotometer stability, this is a prime requisite.

An attempt was made to employ an ordinary toggle switch in the storage battery output. However, the combined voltage drop of the relatively high resistance switch together with that of the pilot lamp was sufficient to appreciably lower the voltage supplied to the spectrophotometer. Under the condition of low input voltage, it was sometimes impossible to balance the instrument satisfactorily. Substitution with the mercury relay switch as indicated in Figure 2 overcame this difficulty.

All electrical connections were made with No. 12 plastic insulated wire. Care was exercised to ensure well-soldered connections in the output leads from the storage batteries. The three leads to the spectrophotometer were sufficiently long to permit inverting the instrument to provide access to the internal "C" batteries.

OPERATION

The following is a list of the manual operations necessary to turn on the spectrophotometer, when the tungsten lamp is to be used.

(1) Turn on switch No. 1 (see Figure 2), which supplies power to the battery charger, the hydrogen discharge lamp power supply, and switch No. 3.

(2) Turn on switch No. 2, which supplies charging current to the storage batteries. If switch No. 2 is on when switch No. 1 is off, the batteries will discharge through the charger.

(3) Turn on switch No. 3, which supplies power directly to the relay coil and indirectly to the spectrophotometer.

(4) Turn the instrument switch to check and turn on the tungsten lamp.

(5) Balance the charge and discharge ammeters by means of the rheostat.

The above steps are carried out in reverse order (omitting step 5) when turning off the power supply.

When the hydrogen discharge lamp is to be used, steps 2 and 5 may be omitted, thereby permitting

operation of the instrument without concurrent charging of the storage batteries. However, experience has indicated that the power supply is sufficiently stable to permit charging the storage batteries during use of the hydrogen discharge lamp; this procedure is being used in these laboratories.

About once every month, the charge on the storage batteries should be checked with a hydrometer. If the charge is low, a period of free charging (steps 1 and 2 above) should be instigated and the storage batteries returned to full charge. At the same time, when necessary, the electrolyte level should be adjusted by the addition of distilled water. Proper care of the storage batteries, as described above, will ensure a longer useful life. A dated record of all maintenance work should be kept as an aid in locating any trouble which may arise.

ADDITIONAL ACCESSORIES

Figure 4 shows some accessory equipment also constructed in these laboratories. The large cell compartment was purchased from Beckman Instruments, Inc. The thermostatted cell compartment was constructed from plans supplied to us by Bell and Stryker.[2]

The plywood boxes have proved very valuable. These accessories (cells, etc.) are quite expensive and justify adequate provision for their storage when not in use.

The box which contains the large cell compartment was designed to hold the small cell compartment as well, thereby providing suitable storage space for either assembly.

Figure 4. Storage Containers for Accessory Equipment

The small block, which holds the 1-cm. cells in an upright position in their box, contains round holes which do not permit the optical surfaces of the cells to touch the sides of the holes. This arrangement permits the cells to drain and immobilizes them, thus preventing breakage. Furthermore, the optical surfaces are protected from becoming scratched.

Following a suggestion by Moeller and Brantley,[3] slide rule hairline indicators were cemented to the wave length and the transmission-density scales. This simple modification minimizes the errors due to parallax and increases the accuracy of the measurements.

[2] Bell, P. H., and C. R. Stryker, *Science*, **105**, 415 (1947).

[3] Moeller, T., and J. C. Brantley, *Anal. Chem.*, **22**, 433 (1950).

AN IMPROVED STIRRER ASSEMBLY

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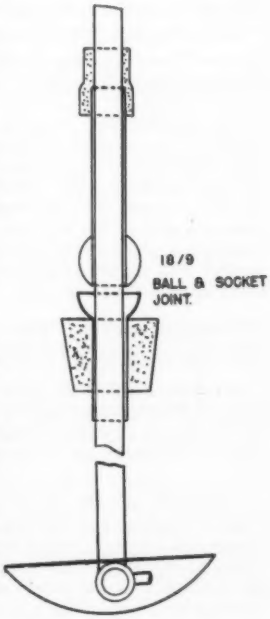
There are many reactions carried out in the average chemical laboratory which require the use of a leak-free stirring-assembly. Several such stirring devices have been described in the literature. However, for some time there has been in use in this laboratory a stirrer seal (see illustration) which possesses several advantages over those which have been described.

This assembly consists of a 18/9 standard ball joint through which passes the stirrer shaft. The socket portion of the joint is either sealed to a standard taper joint or inserted into a cork or rubber stopper and is fitted to the reaction flask. The ball portion of the joint is attached to the stirrer shaft by means of a piece of rubber tubing and rotates with the shaft. This assembly may be used with any appropriate stirrer propeller.

The success of this assembly is dependent upon two factors. It must be so mounted that pressure is constantly exerted upon the seal and the seal must be adequately lubricated.[1]

The advantages of this assembly are its simplicity, ease of construction, and relatively low cost. In this laboratory the stirrer has been used successfully at pressures both above and below atmospheric.

We do not claim originality for this assembly, but because of the interest exhibited in it by visitors to this laboratory, we feel that its description should be published.



[1] For most purposes we have found "Cello-Grease," Fisher Scientific Company, Pittsburgh, Pa., to be a satisfactory lubricant.

SCIENCE AND EDUCATION[1]

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Massachusetts Institute of Technology, Cambridge, Massachusetts, and Worcester Polytechnic Institute, Worcester, Massachusetts

The direction in which education starts
a man will determine his future life.
Plato, 428–348 B.C.

WILHELM OSTWALD (1853–1932), who must be considered as one of the pioneers of modern physical chemistry, visited the United States in 1906. In a book he published a few years later (*12*) he makes a few statements pertaining to science and education which should be taken into far more serious consideration than has been the case so far. He points out that the American college in its present form takes too long to permit the student to reach the state of truly specialized training. This compels us to use the senior year as preparation for specialized studies, thereby depriving the student of nearly one year of still badly needed general education. He also severely criticizes the fact that far too many financial contributions made to our educational institutions are used for the erection of costly buildings, at the request of the donor, leaving nothing for the less conspicuous but nonetheless costly needs of truly scientific and educational equipment. How well Ostwald sized up the basic difference of fitting science into education in pre-Hitler Germany and pre-Stalin Russia, and America forty years ago becomes quite evident from the following citations.

In an editorial which was published four years ago in one of our leading chemical journals there appeared the following statement:

> The dramatic story of the atom bomb brings home to informed Americans the startling and thoroughly disturbing fact that a large proportion of the advances in pure or fundamental research, not only in physics, but in biology, chemistry, medicine, and in practically every field of science, has been made by citizens of other countries. We find that the contributions in pure science coming out of our research institutions compare unfavorably in number with the total reported in the scientific journals devoted to fundamental research (*11*).

A German scientist who visited the United States at that time added the following:

> An essential difference which appears to have been overlooked is the training method used by American universities. Systematic drilling as a method of instruction can provide sound knowledge, but is hardly apt to promote self-reliant thinking and the spirit of research. The excessive use of the textbook, to which the student is bound, works in the same direction (*15*).

Looking at these statements objectively, it must be admitted that they are based on undeniable facts. So far the United States owes its greatness primarily to its unexcelled ability to develop discoveries on a large scale and, if needed, very quickly, as is best exemplified by our synthetic rubber industry. Further proof of how true this is not only in our education but also in industry prior to World War II can be offered with the following fact. When the former chief chemist of one of Germany's largest rubber factories arrived in the United States in the late thirties, he was asked if he would consider it possible to produce polybutadiene rubber (Buna) for 15–20 cents per pound. When he said, "Not immediately, but unquestionably at a later date; just think of the indigo synthesis," he was told that under those conditions no one could be interested. Even his remark that his company gained a lot of experience working with the first experimental batches of Buna made no impression.

Since the end of World War II and all its consequences, the situation has undergone drastic changes. If we want to retain leadership in the world of today it is up to us to develop a young generation which is capable not only of setting production records but also of making new and basic discoveries. That I am not the only one who feels this way is shown in the following quotation taken from a recently issued book written by one of our most outstanding educators: "Those who control our universities and colleges, like most other people, seem only vaguely aware that Western civilization can no longer run along on inertia, that it is in crisis, that it needs morally sound guidance, must have such guidance or perish. They do not seem to realize that things are so basically out of joint that we have no time left for slow and gradual betterment." (*1*)

To prove how true this is I would now like to quote from two addresses made by two leading industrialists at a recent meeting of the New Jersey Chapter of the American Institute of Chemists. This meeting was devoted to the problem: does present education properly train chemists for industry? The first speaker (*2*) had this to say: "My response to the question of whether present education gives satisfactory prepara-

[1] Presented at the Symposium on Comparisons Between English, French, and German Chemical Developments in the Nineteenth Century, which was held under the auspices of the Divisions of History of Chemistry and of Industrial and Engineering Chemistry of the American Chemical Society at its 118th Meeting in Chicago, Illinois, September 3–8, 1950.

tion in fields other than the technical to chemists entering industry is rather categorically 'no.'" The second speaker (*7*) had this to say: "Education provides the future technician with the fundamentals in chemistry and chemical engineering and education will also considerably improve or correct the 'born aptitude,' if the college or university training is well conducted. A weakness in our present educational system is that the young graduate hardly knows what chemists do in industry." The U. S. Commissioner of Education recently made the following statement: "For all the recent progress in general education, there are still a very great number of institutions with curriculums organized in watertight compartments. Efforts to bridge or penetrate the barriers between departments are sometimes jealously resisted." (*9*)

This leads us to the basic problem of how science can best be fitted into our educational system without having to make too drastic changes. I think that I could not do better at this point than to quote the President of one of our leading universities (*4*)[2]:

> One of the difficulties in presenting science as part of general education at both the school and college level is that of selection. The progress in all the sciences in the last three hundred years has been so great that the factual information is enormous. Even the selection of the major principles to be expounded is no easy matter. Questions of the reality of atoms, molecules, electrons, neutrons, not to mention photons and light waves and three-dimensional space, we should want to postpone to a college course. And even at the college level some of us would doubt the student's ability to handle them adequately as part of science. Rather, we should direct our students to study philosophy to see the various types of current answers.

Perhaps of even greater importance for anyone interested in the problem of why science is essential in modern education are the following statements (*5*)[3]:

> What is needed are methods for imparting some knowledge of the Tactics and Strategy of Science to those who are not scientists. But even if we agree that it is not more knowledge about science (more facts and principles) but some understanding of science that is required by the general public our pedagogic problem is not solved. For there are two ways of probing into complex human activities and their products: one is to retrace the steps by which certain end results have been produced, the other is to dissect the result with the hope of revealing its structural pattern and exposing the logical relations of the component parts, and, incidentally, exposing also the inconsistencies and flaws. Philosophic and mathematical minds prefer the logical approach, but it is my belief that for nine people out of ten the historical method will yield more real understanding.
>
> The objective would be to give a greater degree of understanding of science by the close study of a relatively few historical examples of the development of science.
>
> The case histories would almost all be chosen from the early days in the evolution of the modern discipline, as for example certain aspects of chemistry in the eighteenth and nineteenth centuries. The advantages of this method of approach are twofold: first, relatively little factual knowledge is required either as regards the science in question or other sciences, and relatively little mathematics; second, in the early days one sees in clearest light the necessary fumblings of even intellectual giants when they are also pioneers; one comes to understand what science is by seeing how difficult it is in fact to carry out glib scientific precepts.

[2] Reprinted by special permission of Dr. James B. Conant.
[3] Reprinted by special permission of the publisher.

On this side of the ocean we certainly still do very little to give our college students what I would term a general education which would be apt to promote self-reliant thinking, the spirit of research, and how the individual can apply the basic knowledge he should have acquired to the benefit of his future and the future of the nation. An adequate education must involve appreciation of the nature of things, creative art, social relationships, religion, and appreciation of what science stands for (*1*, *3*). How true this is has only quite recently been expressed by the leading scientist of our times, Albert Einstein, in the following words: "Science without religion is lame, religion without science is blind."

This means that we must change our curricula so that our young people are first of all taught how to live and not just how to make a living. In doing this we could give our young generation a sound grounding in those philosophical principles on which the evolution of science is based. This will then also give them a solid foundation on which to develop what they have conceived. Above all, we must teach them that to be a successful scientist, textbook knowledge alone will never suffice and that they first of all must learn how to apply logically the knowledge they have gained. "The true aim of the teacher," Karl Pearson once said, "must be to impart an appreciation of methods and not a knowledge of facts."

The famous French scientist Henri Louis Le Chatelier (1850–1936) once stated that the following factors, given in the order of their importance, were necessary for success in science and education: enthusiasm, judgment, imagination, and a large fund of organized knowledge. To impart these factors to the student in a science course, the teacher himself must be enthusiastic about his subject and present it in an interesting and stimulating manner. This a textbook can never accomplish.

To offer proof of how true these statements are and how important they are in education, I would like to give a few specific examples from that field of science in which I have specialized for so many years, and which has been neglected far too long in this country (*10*), namely, colloid chemistry.

In the Bakerian lecture delivered on February 5, 1857, Michael Faraday (*6*) made the following statements:

> If a pint or two of the weak solution of gold chloride before described be put into a *very clean* glass bottle, a drop of the solution of phosphorus in sulphide or carbon added, and the whole well shaken together, it immediately changes in appearance, becomes red, and being left for six or twelve hours, forms the ruby fluid; too much sulphide and phosphorus should not be added, for the reduced gold then tends to clot about the portions which sink to the bottom.
>
> Fluids thus prepared may differ much in appearance. . . . Those prepared with weaker solutions and in bottles are frequently amethystine or ruby in colour and apparently clear. They often remain unchanged for many months, and have all the appearance of solutions. But they never are such, containing in fact no dissolved, but only diffused, gold. The particles are easily rendered evident, by gathering the rays of the sun (or a

lamp) into a cone by a lens, and sending the part of the cone near the focus into the fluid; the cone becomes visible, and though the illuminated particles cannot be distinguished because of their minuteness, yet the light they reflect is golden in character, and seen to be abundant in proportion to the quantity of solid gold present.

In studying the application of diffusion of solutions through appropriate membranes as a new analytical procedure, Thomas Graham made the following statement (*8*):

The comparatively "fixed" class, as regards diffusion, is represented by a different order of chemical substances, marked out by the absence of the power to crystallize, which are slow in the extreme. Among the latter are hydrated silicic acid, hydrated alumina and other metallic peroxides of the aluminous class, when they exist in the soluble form; with starch, dextrin, and the gums, caramel, tannin, albumen, gelatine, vegetable and animal extractive matters. Low diffusibility is not the only property which the bodies last enumerated possess in common. They are distinguished by the gelatinous character of their hydrates. Although often largely soluble in water, they are held in solution by a most feeble force. They appear singularly inert in the capacity of the acids and bases, and in all the ordinary chemical relations. But, on the other hand, their peculiar physical aggregation with the chemical indifference referred to appears to be required in substances that can intervene in the organic processes of life. The plastic elements of the animal body are found in this class. As gelatine appears to be its type, it is proposed to designate substances of the class as *colloids*, and to speak of their peculiar form of aggregation as the *colloidal condition of matter*. Opposed to the colloidal is the crystalline condition. Substances affecting the latter form will be classed as *crystalloids*. The distinction is no doubt one of intimate molecular constitution.

Perhaps the most striking proof of how important it would be to educate our young generation so that they at least know what science should stand for in their general education, is the discovery of the ultramicroscope by Zsigmondy. This example should not be overlooked by modern educators because it will offer them the best proof for the importance of logical reasoning and the philosophical approach to all problems pertaining to science in education. Richard Zsigmondy was one of the most ardent supporters of the so-called solution theory, but by pure logical reasoning and strict adherence to the truth of experimental evidence he was the first to discover experimental means to solve the problem to a large extent and to prove the so-called heterogeneous theory of colloidal solutions which had already been postulated many years before by Wilhelm Ostwald (*13*). Since no one can describe better than he himself the reasoning that led him, in collaboration with H. Siedentopf, to the construction of what is known today as the ultramicroscope and to the first observations with the use of this new optical equipment, I shall quote verbatim (in translation) his first publication pertaining thereto.

Since these fluids [Zsigmondy is referring to colloidal gold solutions which he had prepared and systematically studied] showed, in general, the mutual properties, and could in practice be differentiated from each other only by their greater or lesser turbidity, I assumed that turbidity is not an essential, but an incidental, characteristic of colloidal gold solutions, occasioned by the presence of larger particles. . . . The addition of a minute quantity of the very turbid fluid to the perfectly clear one sufficed to endow the latter with the polarized dispersion of the former, as evidenced by means of the light cone; and this made evident how small a quantity of coarse gold particles is necessary to produce in a gold solution, assumed to be homogeneous, the diffuse dispersion referred to. . . .

It must be acknowledged, however, that although the facts above referred to were favorable to my view, they gave no evidence of the existence of an optically clear gold solution. I hoped to be able to find out the truth by microscopical examination of the cone of light. . . .

It seemed to me probable that the larger particles assumed to be present in gold hydrosols, whose previously mentioned property of dispersing transmitted light was known to me by the above experiments, could be made individually perceptible by a microscopic examination of the light cone; for if the small particles reflected enough sunlight, even if their size was below the limit of microscopic resolvability, they would, just as were the narrow rays of light, be individually perceptible under the microscope and act to a certain extent as fragments of such light slits. The microscopical investigation should also allow me to determine if the space between the coarser individual particles was optically clear or filled with smaller gold particles.

Those who have had occasion to observe a colloidal gold solution under the ultramicroscope will appreciate the vivid description of the phenomenon given by Zsigmondy in one of his lectures shortly after his epoch-making discovery. Having pointed out that large gold particles float quietly in the fluid and slowly sink to the bottom or else show only an unimportant Brownian movement and that, by considering colloidal solutions as suspensions, one would naturally imagine that the gold particles in these, too, would be as quiet as those in the real suspensions, he added:

How entirely erroneous was this idea! The small gold particles no longer float, they move—and that with astonishing rapidity. A swarm of dancing gnats in a sunbeam will give one an idea of the motion of the gold particles in the hydrosol of gold! They hop, dance, jump, dash together, and fly away from each other, so that it is difficult in the whirl to get one's bearings. . . .

This motion gives an indication of the continuous mixing up of the fluid, and it lasts hours, weeks, months, and if the fluid is stable, even years. . . .

Sluggish and slow in comparison is the analogous Brownian movement of the larger gold particles in the fluid, which are the transition forms to ordinary gold that settles (*16*).

I have picked these examples because a survey of the textbooks now available for the education of our young generation in this branch of science reveals that only one offers this information, thereby not only explaining to the reader what the ultramicroscope stands for but on what logical reasoning its discovery was based. I personally feel that it is the latter which is far more important for a general education in science than to go into great detail regarding its optics.

The United States has today a unique chance to lead the whole world into a better and safer future. It is now up to us to reach this goal or face destruction of all for which the founders of our nation lived and fought. This is the greatest challenge education has ever faced in the United States. Now is the time to make drastic changes in our educational setup. In a world such as the one we are living in today it is our duty to see to it that science is taught to every citizen in a manner he can understand without cramming everyone's brain

with unnecessary dogmas. But even those who intend to devote their lives exclusively to science must be educated comparably to the leading scientists of the nineteenth century. By this I mean that far more attention must be paid to offering our young generation of scientists-to-be all the information at our disposal now pertaining to the historical development of science and what has been accomplished thereby and why a scientist must also have a fairly strong background in philosophy in order to be successful. To accomplish this only those should be encouraged to make the teaching of science on the college level their life work who are prepared to take on a hard job with modest income (*14*), and who have realized that there are other things than money which can give satisfaction in life.

The true purpose of education still should be what Socrates proclaimed, namely, to achieve individual independence and spiritual self-reliance (*13*). The true purpose of science should be to serve, not to dominate or subordinate the whole of life (*12*). The true purpose of education should be to have our young generation learn above all how timely are Plato's words: "It is not the life of knowledge, not even if it included all sciences, that creates happiness and well-being. Without the knowledge of good and evil, the use and excellence of sciences will be found to have failed us."

This can best be accomplished by combining the high spots, so to speak, of the pre-Hitler and pre-Stalin European and American systems of education. This would give our young generation that grounding in those philosophical principles on which the evolution of science is based. Besides this we also must give them a basis on which they can form their own concepts. Above all, however, we must teach them that textbook knowledge alone will not suffice. This can only be done if the students never get the impression that an iron curtain exists between themselves and their teachers.

It would be beyond the scope of this paper to go into a detailed discussion of the changes which I would consider most essential. Here we have a unique opportunity for a committee composed of experts in education, both in pre-war Europe and in the United States, and leaders in science to work out a truly satisfactory educational system.

If we do not make drastic changes soon, it might be too late, for time is moving fast, and not only our education, but the whole world might be facing a crisis.

ACKNOWLEDGMENT

The author expresses his appreciation to Dr. Richard Weil, Detroit, Michigan, whose comments stimulated many of the ideas in the above paper.

LITERATURE CITED

(1) Bell, B. I., "Crisis in Education," Whittlesey House, McGraw-Hill Book Co., New York, 1949.
(2) Brown, C. L., *The Chemist*, 27, 161 (1950).
(3) Brunner, E., "Christianity and Civilization," Charles Scribner's Sons, New York, 1949.
(4) Conant, J. B., "Education in a Divided World," Harvard University Press, Cambridge, 1948.
(5) Conant, J. B., "On Understanding Science," Yale University Press, New Haven, 1947.
(6) Faraday, M., *Phil. Trans. Roy. Soc.*, 147, 145 (1857).
(7) Frey, A. J., *The Chemist*, 27, 165 (1950).
(8) Graham, T., *Phil. Trans. Roy. Soc.*, 151, 183 (1861).
(9) McGrath, E. J., *The Scientific Monthly*, 71, 118 (1950).
(10) Merrill, R. C., *J. Eng. Ed.*, 39, 521 (1949).
(11) Murphy, W. J., *Ind. Eng. Chem.*, 38, 665 (1946).
(12) Ostwald, W., "Die Forderung des Tages," Akad. Verlagsges., Leipzig, 1911.
(13) Ostwald, W., "Lehrbuch d. allgem. Chemie," W., Engelmann, Leipzig, 1887, Vol. II.
(14) Payne, F., *Science*, 111, 589 (1950).
(15) Planck, R., *Chem. Eng. News*, 27, 1784 (1949).
(16) Siedentopf, H., and R. Zsigmondy, *Ann. Phys.*, 10, 1 (1903).

SUMMER COURSES IN CHEMICAL MICROSCOPY

Instruction in chemical microscopy will be given at Cornell University during the coming Summer Session, if warranted by advance enrollment.

The introductory course includes lectures and laboratory work on micrometry and particle-size determination, optical properties of crystals and their behavior, lens systems and illumination, photomicrography, and studies of textile and paper fibers. A course in microscopical inorganic qualitative analysis will also be given.

The session begins July 2 and continues for six weeks, but persons not desiring University credit may be able to cover in a shorter period those portions of the field most suited to their needs. Inquiries should be addressed to C. W. Mason, Olin Hall, Cornell University, Ithaca, New York.

VALENCY AND THE PERIODIC TABLE

GEORGE GLOCKLER and ALEXANDER I. POPOV
State University of Iowa, Iowa City, Iowa

THE value of the periodic table in the teaching of all chemistry need hardly be emphasized. A single page summarizes thousands of facts concerning physical and chemical properties of the 98 known elements, and elevates inorganic chemistry from a collection of seemingly unrelated data to a systematic science. So great is the success of Mendeleev's and Lothar Meyer's discovery that its limitations are not always recognized and stressed.

It is becoming more and more evident that in many cases the analogies predicted by the periodic table are only approximate, and that the generalizations cannot be carried too far. Only in the light elements do the chemical and physical properties strictly obey the periodic law. As the electronic structure becomes more complex, and the inner orbits begin to fill, the chemical analogies become less pronounced.

The greatest difficulty in drawing up a periodic table is the assignment of position to the rare earth elements. In the more conventional types of periodic tables the rare earths are usually separated from the main body of the table and are presented apart in a horizontal line. After the discovery of the transuranium elements Seaborg (*1*) postulated the existence of a second rare earth series beginning with thorium, which he proposed to call the "actinide series." The second incomplete rare earth series was separated from the table and placed in a horizontal line below the lanthanides. This procedure resulted in thorium, protactinium, and uranium losing their positions as homologues of hafnium, tantalum, and wolfram, respectively. Recently it was pointed out by Haissinsky (*2*, *3*), Paneth (*4*, *5*), Sidgwick (*6*), and others, that in doing so Seaborg has completely neglected all the chemical evidence relating the withdrawn three elements to columns IV, V, and VI of the periodic table. Such separation of these two series of elements from the main table would indicate that their chemical properties are as similar as the chemical properties of the isotopes of *one* element. This statement is not true for the lanthanides, where not only is there considerable difference in chemical properties between, say, praseodymium and lutetium, but also some of the elements possess stable oxidation states different from three. These differences are still more pronounced in the actinides. The chemical properties of neighboring elements of the two series may be similar, but in many cases no more so than the neighboring transition elements, and in the case of thorium, protactinium, and uranium, certainly much less.

Since the periodic table should represent the variation of chemical properties of the elements as a function of the atomic number, it seems reasonable to expect that all the elements should be included in a single picture. Such attempts have been made in the past. For the most part they were rather complicated arrangements, often in three dimensions (*7*, *8*). Another table of this type is the modification of the Bohr-Thomsen-Akhumov (*9*, *10*, *11*) periodic table shown in the figure. It includes all the known elements and is thought to be of a much simpler form than previous attempts in this direction. The inclusion of the neutron can be justified by regarding it as an "element" with atomic number 0. The number of electrons in a shell is given by the expression $2n^2$ (*12*), where n is the principal quantum number. In the case of the neutron it can be said that $n = 0$ and the neutron is the first member of the periodic table with zero nuclear charge (*13*).

While the addition of electrons occurs in the outer shells, the variation of the chemical properties smoothly follows the periodic law. Elements in the same family have, in general, similar outer electronic configurations and, therefore, the same spectral terms for the ground state of the atom.

The first major discrepancy occurs in the sixth row. The first member, cesium, has xenon configuration and one *6s* electron; the *6s* shell is completed in the next element, barium, and the next one, lanthanum, has one *5d* electron. Cerium adds two *4f* electrons while losing the *5d* one. Its electronic configuration is quite different from its homologues, zirconium, hafnium, or thorium. The *4f* electrons are somewhat more strongly bound than the *5d* ones and, therefore, it is possible for cerium to form a trivalent ion with the configuration $Xe4f^1$ (Xe = xenon configuration).

However, cerium also readily loses the last *4f* electron and in doing so the tetravalent ion becomes a homologue of the elements in the fourth column and has the same electronic configuration in the outer orbits.

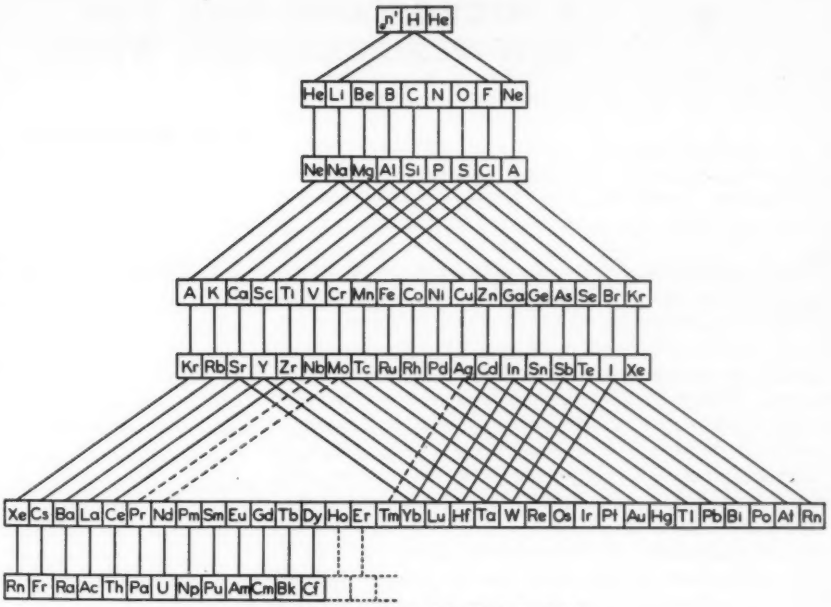
The next rare earth element, praseodymium, has three *4f* electrons in the ground state. It easily gives the trivalent ion with the structure $Xe4f^2$ and can even lose another of the *4f* electrons to give the tetravalent oxide. The *4f* shell becomes more stable, and, as was shown by the recent work of Marsh (*14*), Rabideau and Glockler (*15*), and McCullough (*16*) the pentavalent state of praseodymium, which would be homologous to the elements in the fifth column, is, as yet, unknown. In neodymium, the *4f* shell becomes even more stable and the +3 oxidation state seems to be the only one found so far (*17*).

With ytterbium, the *4f* shell is complete and this explains the ease with which this element can be obtained

in the divalent state, analogous to zinc and cadmium. The next element, lutetium, is akin to the trivalent elements in the column III-B.

The question as to where do *5f* electrons begin to be added is still largely unsettled. Spectroscopically they were found in uranium (*18*), but not in thorium (*19*). Recent investigation of the +3 oxidation state of thorium (*20*) seems to agree with the view that this element does not possess any *5f* electrons.

Seaborg (*1*) has stressed, however, that the differences in the energy levels of *5f* and *6d* electrons may be of the order of magnitude of a chemical reaction. Thus the presence or the absence of the *5f* electrons in the neutral atoms of the first three members of the actinides is relatively unimportant, since the chemical analogies are based on their highest oxidation states. This view makes thorium, protactinium, and uranium *bona fide* members of columns IV, V, and VI of the periodic table, without denying the possible existence in their neutral atoms of the *5f* electrons. It is seen that the modified periodic table does in fact relate the disputed elements to the rare earths as well as to their more natural chemical homologues.


n H He
He Li Be B C N O F Ne
Ne Na Mg Al Si P S Cl A
A K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Kr Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Xe Cs Ba La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Rn Fr Ra Ac Th Pa U Np Pu Am Cm Bk Cf

Proposed Modification of the Periodic Table

It is quite true that neither the oxidation states of praseodymium and neobium, or neodymium and molybdenum, or their chemical properties are in any way similar; however, this is inevitable because of the sudden appearance of the *4f* level at this point.

A glance at the conventional form of the periodic table shows that at present the oxidation state is not necessarily the guiding principle in the assignment of positions to elements. In some cases, as with silver, the lowest valence determines the position of the element; in other cases, as with vanadium, it is the highest. It is also evident that the oxidation state determining the location of an element in the table is not necessarily the most stable one. Such is the case of Cu, Au, Sn, Pb, and some of the halogens. In some cases (O^{+6}, F^{+7}, Br^{+7}, transition elements) the oxidation state indicated by the column remains unknown.

With further development of inorganic chemistry and especially with the increased knowledge of the "unusual oxidation states" (*21*), valency ceases to be the paramount criterion for the position of an element in the periodic table. Frequent compromises have to be made as to the location of an element in the periodic table, depending on the choice of the physical or chemical property used as a guide (*3*). Many different arrangements are possible, and the periodic table proposed herewith is one of them.

LITERATURE CITED

(1) Seaborg, G. T., *Science*, **104**, 379 (1946).
(2) Haissinsky, M., *Bull. Soc. Chim. France*, **16**, 668 (1949).
(3) Haissinsky, M., *J. de chim. phys.*, **47**, 415 (1950).
(4) Paneth, M., Les Isotopes, "Congres Solvay" Brussels, **1947.**
(5) Paneth, M., *Nature*, **165**, 748 (1950).
(6) Sidgwick, N. V., "The Chemical Elements and Their Compounds," Oxford University Press, London, **1950.**
(7) Estee, C. R., Ph.D. Thesis, State University of Iowa, August, **1947.**
(8) Clark, J. D., *Science*, **111**, 661 (1950).
(9) Bohr, N., *Z. physik.*, **9**, 1 (1922).
(10) Thomsen, J., *Z. anorg. Chem.*, **9**, 192 (1895).
(11) Akhumov, E. I., *J. Gen. Chem. U.S.S.R.*, **17**, 1241 (1947).
(12) Ruark, A. E., and H. C. Urey, "Atoms, Molecules and Quanta," McGraw-Hill, New York, **1930**, p. 273.
(13) Akhumov, E. I., *J. Gen. Chem. U.S.S.R.*, **16**, 961 (1946).
(14) Marsh, J. K., *J. Chem. Soc.*, **1946**, 17.
(15) Rabideau, S., and G. Glockler, *J. Am. Chem. Soc.* **73**, 488 (1951).
(16) McCullough, J. D., *J. Am. Chem. Soc.*, **72**, 1386 (1950).
(17) Popov, A. I., and G. Glockler, *ibid.*, **71**, 4114 (1949).
(18) Schuurmans, P., *Physica*, **11**, 419 (1946).
(19) Meggers, W. F., *Science*, **105**, 514 (1947).
(20) Warf, J. C., p. 2Q Abstract, 118th Meeting of the A. C. S., Chicago, Illinois, Sept. 3–8 (1950).
(21) Kleinberg, J., J. Chem. Educ., **27**, 32 (1950).

A MICROSCOPE CELL FOR LOW-TEMPERATURE WORK

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Pure Oil Company, Crystal Lake, Illinois

THE examination of materials with a microscope at low temperatures using a liquid-cooled cell to contain the specimen is prevented by the condensation and subsequent freezing of moisture on the cell or on the slides containing the sample if they are not completely enclosed. Unless some facility such as an absolutely dry room, a cold room, or a refrigerated box for the microscope is available, the observation of crystallization or other phenomena at temperatures below the dew point of the surrounding air is impossible. This problem was encountered and solved by the author while studying wax crystallization at temperatures down to −40°F. The simple piece of apparatus described herein was devised and constructed at that time and can be easily duplicated in any laboratory.

Figure 1 shows an isometric cross section through the center of the base and cover of the cell which was used. The large cylindrical holes at the center of the cell are for the objective lens and light from below. The small channel shown at the edge of the hole in the base is one of four through which dry gas is bled to the cylindrical openings outside the glass observation panels. The position of the observation panels is indicated by the dashed lines, and the platforms just above the lower panel support the sample slides. The holes in the ends admit and conduct cold gas through the cell above and below the sample slides and to the small channels. The gas bled through the channels serves to keep moist air away from the glass and also evaporates the moisture that collects on the glass when samples are changed.

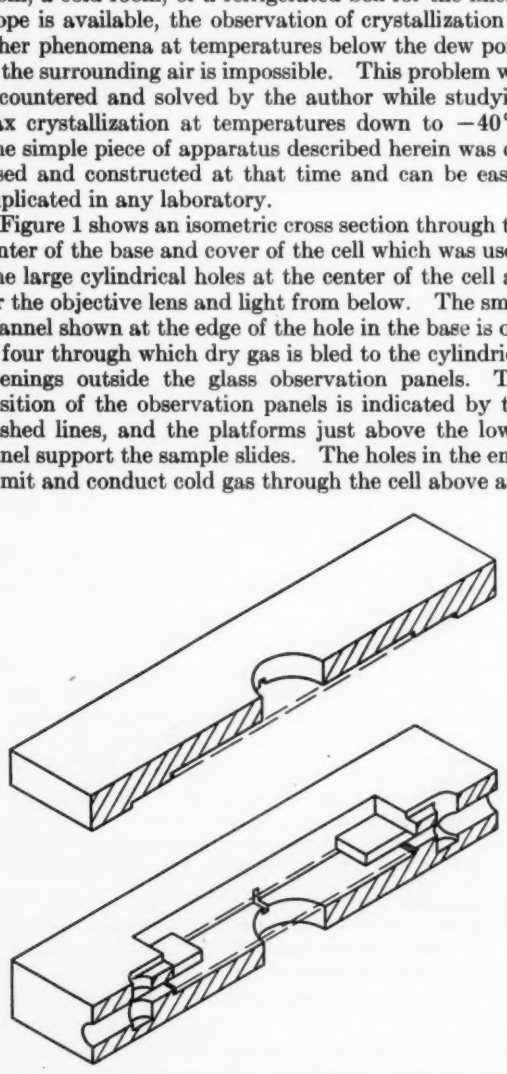


Figure 1. Cross Section through the Center of Microscope Cell

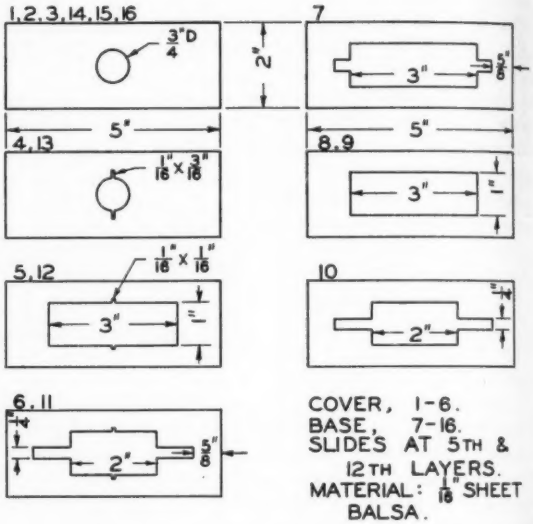


Figure 2. Patterns for Laminated Microscope Cell

The auxiliary apparatus consists of a gas cylinder, carbon dioxide or nitrogen, with pressure-reducing valves, a glass venturi flowmeter or other measuring device, a copper tubing coil of about ten 3-inch diameter turns, an insulated dry-ice-acetone bath large enough to hold the coil and to prevent bubbling over of the acetone, pressure tubing, rubber or plastic, for connections, and a potentiometer if temperatures must be known accurately.

In operation, gas flows from the tank through the venturi to the copper coil in the dry-ice-acetone bath. When carbon dioxide is used as the coolant the temperature of the bath must not be below −78.5°C. The cold gas passes through tubing, which should be insulated in order to prevent the condensation of moisture, to the cell on the microscope platform. The gas escapes from the cell through the opposite end and through the channels above the panels. If an insufficient quantity of gas escapes through the channels to the windows the outlet line of the cell may be pinched off slightly. The amount of gas and the temperature of the bath determine the temperature of the cell.

The temperature of the material on the slide can be

determined by correlating that temperature against the temperature in the cell. This is done by freezing water on the slide, or another pure liquid with freezing point in the temperature range desired, while measuring the temperature in the cell by means of small thermocouples inserted through needle holes in the sides of the base of the cell.

The cell is constructed of balsa wood, an excellent insulator, and if $^1/_{16}$-in. sheet balsa is used the patterns shown in Figure 2 may be followed. The holes indicated in the ends of the cell in Figure 1 should be cut after cementing the layers together. A sharp cork borer will suffice. Short lengths ($1^1/_4$ inches) of glass tubing are cemented in the holes at the ends of the base for connections with the coil and the exhaust line.

Either a recessed slide or a hanging drop slide may be used to contain the sample while a flat slide is used as a cover. The windows are flat slides and are cemented in place as the layers are assembled. All slides are 1 × 3 inches and should fit snugly in place. Large rubber bands hold the cover down tightly, and, if passed around the table of the microscope, hold the cell steady also.

The cell shown is suitable for magnifications up to 100 ×. The dimensions of the cell can be altered to permit greater magnifications or other applications. The important feature is the supply of dry gas to the observation panels of the cell. The objective lens must in all cases nearly fill the top opening in order to insure a seal against moist air. The present design allows the sample to be moved over a distance of about $^1/_8$ inch without breaking the seal. If a greater area must be observed, a movable section like the top layer, but shorter, may be added above the cover of the cell and the hole in the cover changed to a slot of the desired dimensions.

IT'S YOUR DIVISION

DIVISION OF CHEMICAL EDUCATION
of the American Chemical Society

SUMMER is still two months away and the fall even farther, yet it is not too early to begin planning on attendance at the 120th Meeting of the A. C. S. which is to be held in New York to celebrate the 75th anniversary of the founding of the Society. The preliminary program covering the meeting dates September 4 through 7 is listed in *Chemical and Engineering News* for April 2 but a further amplification of the description of the program of the Division of Chemical Education might help in planning your attendance at the meetings.

Seven symposia have been planned by the Division. No general papers will be given at the New York meeting. Each of the symposia will consist of invited papers only with the exception of the session on Lecture Demonstrations, chairmaned by H. N. Alyea of Princeton. He is soliciting ideas from which the best will be chosen for use at the meeting. Yours may be submitted by writing directly to him.

The other symposia cover the gamut of chemical education starting with the discussion of College-High-School Relationships in Chemistry under the direction of E. C. Weaver of Phillips Academy. What to Leave Out of General Chemistry (James M. Holbert, University of Chattanooga), Subject Matter versus Student (L. L. Quill, Michigan State College), Contents of the Basic Courses in Chemistry (Philip J. Elving, Pennsylvania State College), and Graduate Instruction (Henry Bent, University of Missouri) complete the coverage of the entire training curriculum. In addition the Division is cooperating with the Division of Physical and Inorganic Chemistry in presenting a symposium on Bond Energies, Force Constants, and Bond Distances (George H. Glockler, State University of Iowa). These seven symposia will fill all the available hours Tuesday through Friday since none of them will run concurrently, and Wednesday afternoon is being reserved for the special anniversary celebration of the Society.

An additional highlight of the program of the Division will be the luncheon to be held on Thursday, September 6. President Conant of Harvard, an ex-chemist who is not so "ex'd" that he has lost interest in chemistry, will be the luncheon speaker. One of his greatest recent interests has been experimentation at Harvard with a beginning chemistry course, and he will discuss some of his ideas and their results under the title, "The Place of History in Teaching Chemistry."

Divisional dues, $1 per year, should be sent to F. D. Martin, Purdue University, W. Lafayette, Indiana, in anticipation of the Fall meeting so that abstracts of the symposia may be received before leaving for the meeting.

Your Divisional Officers are now soliciting suggestions for symposia for the 1952 meetings. Your suggestions for such symposia would be welcome for it is only by keeping in touch with the interests of the individuals in the Division that adequate schedules can be arranged.

J. A. CAMPBELL, *Chairman*

MEN OF THE PRIESTLEY CENTENNIAL

William K. Kedzie from Kansas[1]

SISTER MARY GRACE WARING
Marymount College, Salina, Kansas

MANY of the early settlers of the Kansas territory were well educated, and the residents in the vicinity of Manhattan, Kansas, had established Bluemont Central College as early as 1858. The bill for the admission of Kansas as the thirty-fourth state of the Union was signed by President Buchanan on January 29, 1861. President Abraham Lincoln approved the Morrill Land Grant Act which provided for the offering of a grant from the public lands to each state in the Union for the endowment and support of at least one college on July 2, 1862. Among other provisions, the college thus maintained should teach such branches as are related to agriculture and the mechanical arts. Kansas accepted the provisions of the Land Grant Act on February 3, 1863; and on February 11, of the same year, Manhattan, Kansas, was designated as the location, in response to an offer made by the Trustees of Bluemont Central College, to transfer the property belonging to that College Association to the state of Kansas, for the establishment of the Kansas State Agricultural College.

The college catalogues from 1863 to 1873 show that a number of different curricula were offered. The classical curriculum was the chief basis of instruction for several years, and the degree of Bachelor of Arts was awarded to most of the graduates up to and including 1876.

One of the great difficulties of this period at the Kansas State Agricultural College was the almost nonexistence of men who were competent to give college instruction in agriculture and in sciences related to that industry. There was controversy among the members of the State Board of Regents, the College faculty, and the townspeople of Manhattan and surrounding towns concerning the scope of the college and the subjects which could or should be taught within the provisions of the Morrill Act. In 1873 the Kansas legislature passed a law reorganizing the Kansas Board of Regents of all state educational institutions. Soon after, the new Board of Regents elected the Rev. John A. Anderson of Junction City, Kansas, to the presidency of the Kansas State Agricultural College to replace President Joseph Denison who had been forced to resign. The result was a radical change of policy, so that under the new administration the school of literature was discontinued and a school of agricultural and mechanical arts was organized.

William Knowlton Kedzie accepted an invitation to establish a department of chemistry and physics under the new régime. Previous to this time any work offered in these subjects had been handled by the professor of natural philosophy. Mr. Kedzie assumed his duties on September 1, 1873, at which time the whole amount of chemical apparatus and supplies was kept in a small box.

During the first year Mr. Kedzie taught classes in inorganic chemistry, chemical physics, French, reading and orthography, and a weekly class in rhetoric. Only five months after he had started instruction at the college, W. B. Christopher of the Farmers' Cooperative Association, after visiting the college made the following comment:

> This gentleman has been in the college but a short time, sufficiently long however to show that he is destined to stand in the front ranks of the profession. . . . I was particularly pleased with the confidence and self-reliance with which he moved. . . . Let it suffice to say that theoretical and practical competency is stamped on laboratory and classroom.[2]

During the summer following Mr. Kedzie's coming to the Kansas State Agricultural College, an event, notable throughout the world, was celebrated at Northumberland, Pennsylvania, concerning which W. George Waring, reporter for the occasion, wrote:

> This usually quiet town (Northumberland, Pennsylvania) was early astir, the streets being thronged with representatives to the convention of the centennial of chemistry, to celebrate the discovery of oxygen by Joseph Priestley, whose remains lie here. Before the hour of organization the school house, with large seating capacity, was well filled, there being little or no standing room. . . . Among the most prominent chemists were: . . . R. C. Kedzie, of the State Agricultural College, Michigan, (and his son) W. R. (K.) Kedzie of the State Agricultural College of Kansas.[3]

Perusal of the roster drawn up by the secretary of the

[1] Presented before the Division of the History of Chemistry at the 118th Meeting of the American Chemical Society in Chicago, September 6, 1950. This is the second of a series of papers [See, "The Priestley Centennial, turning point in the career of W. George Waring," J. CHEM. EDUC., 25, 647 (1948).] revealing the early history of chemistry in the United States, by relating the lives and works of those who attended the first assembly of chemists in this country and prepared the ground for the organization of the American Chemical Society two years later.

[2] CHRISTOPHER, W. B., "Report of W. B. Christopher to Farmers' Cooperative Association," *Topeka Commonwealth*, January 21, 1874.

[3] WARING, W. GEORGE, "Chemistry's Centennial," *New York Herald*, p. 3, August 1, 1874.

Priestley Centennial shows that W. K. Kedzie was the only delegate present who represented territory West of the Mississippi river. *The Manhattan Nationalist* of August 7, 1874, stated that Professor Kedzie seemed to have taken an active part in the Chemists' Centennial proceedings over the grave of Joseph Priestley. At the seventh annual meeting of the Kansas Academy of Science at Topeka on October 5, 1874, Professor W. K. Kedzie read a paper "On the Priestley Centennial."[4] Later, he delivered a lecture before the students of the Kansas State Agricultural College on the life, character, discoveries, and persecutions of Joseph Priestley.

No doubt this meeting at Northumberland, Pennsylvania, had a profound influence upon William K. Kedzie's future activities. At the Centennial, all chemists were encouraged to strengthen the chemistry section of the American Association for the Advancement of Science. In this, Professor Kedzie did his full part, for he not only attended subsequent annual meetings of that organization but took a vital part in them, sometimes presenting as many as three papers on one program, and by holding offices, such as curator, and commissioner of mineralogy and chemistry. He joined the American Association for the Advancement of Science in 1876.

The Priestley Centennial, which marked the first assembly of the chemists of the United States, was a prelude to the founding of the American Chemical Society, the actual organization of which took place on April 6, 1876, with William Kedzie elected as a charter member.

Refreshed scientifically by recent contact with men of kindred interest, Professor Kedzie started the term beginning September, 1874, with new zest. His attention was now turned entirely to science and to scientific applications. *The Manhattan Nationalist* of November 20, 1874, carried an item in which Professor Kedzie wanted it distinctly understood that he was teaching the sciences pertaining to his department and denied that he was teaching French that term. Some of the courses offered were: inorganic chemistry, organic and analytical chemistry, agricultural chemistry, chemical physics, mineralogy, meteorology, geology, household chemistry, and special hygiene, while assaying, pharmaceutical chemistry, and photography were taught to more advanced students. The laboratory was crowded to capacity, a larger number seeking instruction than could be conveniently accommodated.

The New York Weekly Journal of Commerce of August 6, 1874, published an article concerning the Priestley Centennial, in which the editor decried the fact that American chemists were making no original discoveries, that they were doing little more than borrowing from the other side of the Atlantic. Professor Kedzie felt that it was necessary for him to tap original sources, so he secured permission from the Board of Regents for six months' leave of absence for

[4] *Transactions of the Kansas Academy of Science*, "Proceedings of the Society," Reprint Vols. 1, 2, 3, p. 93 (1896), Miller Bros., Topeka, Kansas.

William K. Kedzie

the sole purpose of visiting European laboratories, and of obtaining information on European techniques of farming. The trip was made at his own expense, but the State Board of Agriculture appointed him to act as its commissioner in the investigation of experiment stations and agricultural societies. Official letters of introduction from Thomas A. Osborn, then Governor of Kansas; General Eaton, the U. S. Superintendent of Public Instruction; Hamilton Fish, U. S. Secretary of State; and others, gained for him a most cordial and courteous attention, so that every facility in European institutions was placed at his disposal. He visited and carefully studied the laboratories of prominent univerisities in Europe: Bonn, Berlin, Leipzig, Göttingen, Halle, Heidelberg, Wiesbaden, Vienna, Geneva, Collège de France, University of Paris, and Owen's College at Manchester in England. His tour lasted from April 12 to August 25, 1875, when he arrived in Manhattan, full of knowledge, energy, and ambition.

When William Kedzie came to the college in 1873 he was given a lecture room and a laboratory on the north side of the old Bluemont building. The water supply for his department was in a barrel, while other facilities were comparable. In 1875 the department of chemistry and physics used the east half of the second floor of the building first known as the barn and later as Farm

Machinery Hall. On the basis of studies in the European laboratories, Professor Kedzie drew up a plan for a chemical laboratory, for which the state made an appropriation of $8000. In addition to a heavy teaching load he supervised the construction of the new building, which was completed in October of 1876. The one-story building was of fine gray limestone and was considered at that time as second to none in the whole West. The interior of the building was destroyed by fire in 1900, but the walls still stand, and today it has very much the same exterior appearance. It is now designated as Mathematics Hall.[5]

All of this time the extracurricular accomplishments of Professor Kedzie were amazing. He made daily meteorological reports, published numerous scientific papers and articles on an astounding variety of topics, such as: "Salt in Kansas," "Ozone in the Kansas atmosphere," "Tempered glass," "Nebraska hot bluff," "Farm culture in Europe," "Concerning sorghum," "A cheap hygrometer for Kansas," "Concerning hail," "Again to the front (practical scientific education)," "The danger and the remedy (The potato-bug)," "The valley of the Solomon," "Influence of height upon rainfall," "Concerning a popular humbug (powders on sale for preventing gasoline explosions)," "Thermometers," "Iola mineral well," "Great Spirit Spring of Mitchell County (Waconda Springs)," "Bell Telephone," "Climate makes the crop," "Common air liquefied," "Silver in southern Kansas," "Chemical review of the grasshopper question," "Clawson wheat," "The sugar group," "Corn smut," "Photography as a woman's art," "Elementary science for the common schools," "Gunpowder as a civilizer," "Tin and tin salts."

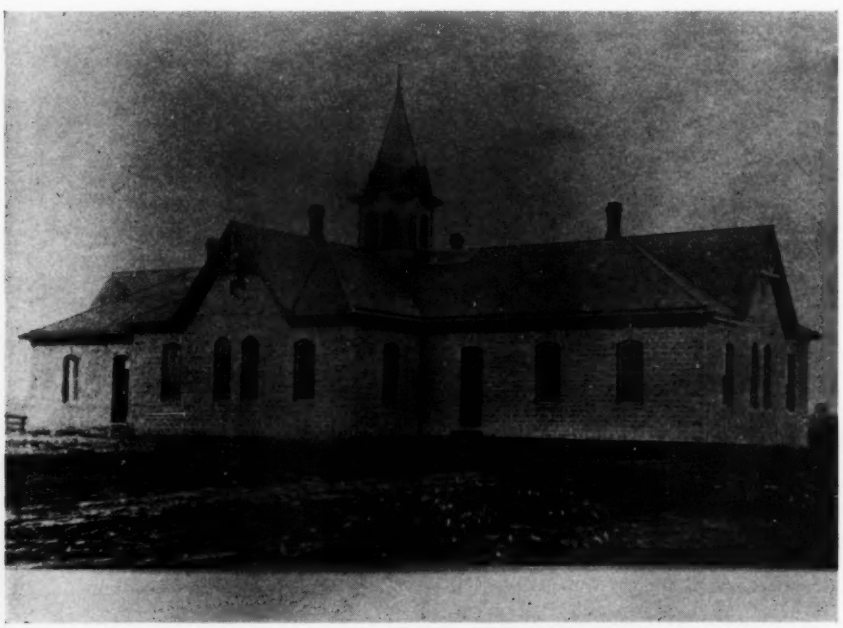
William Knowlton Kedzie was well known also as a popular lecturer on cultural as well as scientific subjects. In any kind of weather his audience filled the hall well in advance and remained spellbound to the end. He talked on student life in Europe, Switzerland and the Swiss, Stratford-on-Avon, and many other topics before state organizations, clubs, and societies in Manhattan and throughout the state. His talks were illustrated, spiced with humor, poetry, and eloquence. A paper on elementary science in the common schools, given at the State Teachers Meeting in Emporia in 1877 could easily pass as a part of a similar program in 1951.

In 1875 five barrels of salt a day were being manufactured at Alma, Kansas, by evaporation of brine pumped from a salt well. Professor Kedzie predicted that the day was not far distant when Kansas would produce her own salt instead of sending a thousand miles away for it. In 1941 Kansas produced 781,014 tons of salt valued at $3,254,828. It is estimated that 5000 billion tons of salt lie beneath the surface of Kansas.

Professor Kedzie was the first to hold the position of chemist as a member of the State Board of Agriculture, in which capacity he ran many analyses of soils and other materials. He was chemist for the state in two murder cases. Evidence produced from his analyses freed one prisoner and convicted the other to life imprisonment in the federal prison at Leavenworth. He made a collection of minerals for the college, helped prepare the Kansas state exhibit for the Philadelphia exposition, wrote and published a geology text for the elementary schools, and prepared a students' handbook of elementary chemistry. Having no suitable texts for courses in inorganic chemistry, physics, and chemical analysis, he issued daily full abstracts of his lectures to each student, and used his own "Manual of Quantitative Analysis."

Professor Kedzie owned the first telephone which

[5] The author did laboratory work in Qualitative Analysis in this building in the summer of 1922. At that time it was known as the Chemistry Annex, No. 1. She received the degree of Master of Science, with major in chemistry and minor in physics, from the Kansas State Agricultural College in 1926.



Courtesy of J. T. Willard, Historian at Kansas State College

Chemistry Building in 1876, as Planned and Erected by William K. Kedzie

came to Kansas and spent one of his vacations touring the state to demonstrate its use. Together with some of his friends, telephone parties became a unique form of entertainment. *The Industrialist* of December 15, 1877, describes one of the events in detail.

Professor Kedzie placed six different homes on the telephone lines, where at eight o'clock, parties varying from four to fifteen each, of ladies and gentlemen, were gathered. Some of these homes in Manhattan were over two and a half miles apart. Music was furnished by the different divisions of the party; at one place was an organ, at another a piano, then a cornet, a harmonica, and at still another a violin. An unusual experiment was the singing of a duet by persons two miles apart, followed by a more remarkable quartette, the members being at four different telephone locations. The notes came with a clearness and softness that suggested the supernatural, and the least variation was more quickly noticed than in the room with the singers. While the timing was not absolutely perfect, it was much better than that kept by many choirs.

In the summer of 1878 Mr. Kedzie resigned his chair at the Kansas State Agricultural College and accepted an appointment as professor of chemistry and mineralogy in Oberlin College, Oberlin, Ohio, where he introduced laboratory instruction in chemistry. Mr. Kedzie was well-liked at Oberlin and his name frequently appeared in the student publication there, but his tenure of professorship was brief. He became ill in January of 1880 and died on April 14 of that year at East Lansing, Michigan.

PERSONALITY AND FAMILY LIFE

William Knowlton Kedzie, the son of Robert Clark Kedzie and Harriet Eliza Fairchild, was born at Kalamazoo, Michigan, July 5, 1851. He was graduated from the Michigan State Agricultural College in 1870 at the age of 19. The next two years were spent in study at the Sheffield Scientific School at Yale, after which he assisted his father in the college at Lansing, Michigan. In July, 1876, Mr. Kedzie married Ella Gale, an attractive young lady attending the Kansas State Agricultural College, and they went to the Philadelphia Centennial on their wedding trip. They were blessed with two children—William Roscoe, who died in 1940, and Ella Pearl, now living in East Lansing, Michigan. Mrs. Ella Pearl Plant wrote recently that her father loved music, literature, and art, and that he had the reputation of being very meticulous in all his habits.

Three students who attended Professor Kedzie's classes over seventy years ago are still living, all of whom paid high tribute to his teaching: Mrs. Nellie Sawyer Kedzie Jones, who married a brother of W. K. Kedzie, stated that in his teaching, Professor Kedzie selected the topics as he pleased, including several lectures on the chemistry of foods. Because he was the first to introduce household chemistry at the Kansas State Agricultural College, she believes that Professor Kedzie was the first instructor at the college in what is now called home economics. Mr. W. H. Sikes wrote that students were inclined to neglect other studies in order to prepare chemistry lessons, as Kedzie was strict and would brook no lazy or makeshift student. Mrs. Ella Child Carroll related that the girls wore calico aprons to Kedzie's laboratory; that he had long side whiskers which he would twirl rapidly when either amused or provoked, which habit was the cause of much merriment to the students. He was so well liked by the students that his classes were crowded and this was the cause of jealousy on the part of fellow instructors.

One biographer has described William Knowlton Kedzie as a gentleman and scholar, with the ability to impart his energetic manner to his pupils. He was tall, well formed, had brown hair, dark eyes, and a goodly face. He was a man of integrity and publicly professed the Christian religion. It was observed in his obituary that most men had only begun life in earnest at the age of 28, but Professor W. K. Kedzie at that age had already accomplished more than the average person in a whole life's span.

ACKNOWLEDGMENT

I am grateful to Mary Frances Dreese, a student, who assisted in collecting data for this paper and who presented a sketch of the life of William Kedzie at the chemistry division of the eighty-first annual meeting of the Kansas Academy of Science at the Kansas State College, Manhattan, Kansas, April 29, 1949; to Dr. J. T. Willard, historian at the Kansas State College, who gave generously of his time for consultation, permitted the use of information from his files, and furnished pictures. I also appreciate personal items and pictures furnished by Mrs. Nellie Sawyer Kedzie Jones and Mrs. Ella Pearl Plant, and the courtesy of others who contributed to the writing of this paper.

LITERATURE

CONNELLY, WILLIAM E., "Kansas and Kansans," Lewis Publishing Co., Chicago, 1919, Vol. 2.

Handbook of the Kansas State Agricultural College, Manhattan, Kansas, printed by *The Nationalist*, Manhattan, Kansas, 1873.

Kansas Industrial Development Commission, "Let's Look into Kansas," State Printing Plant, Topeka.

Kansas State Agricultural College, "Annual Reports to the State Board of Regents," Vols. 1–9; "Biennial Reports," Vols. 1–6 (1868–88).

Kansas State Board of Agriculture, "Annual Reports," Vols. 1–5 (1872–76); "Biennial Reports," Vols. 6–8 (1877–82).

KEDZIE, W. K., "Papers presented and offices held," *Transactions of the Kansas Academy of Science*, Vols. 1–3 (1872–74), Reprint by Miller Bros., Topeka, 1896; Vols. 4–7 (1875–80), Reprints by W. Knaus, McPherson, Kansas, 1906.

KEDZIE, W. K., "The Elements of Agricultural Geology for the Schools of Kansas," Wilson, Hinkle and Co., Cincinnati, Ohio, 1877.

KEDZIE, W. K., "Announcements and papers on scientific subjects," *Kansas Farmer*, 1874–79.

KEDZIE, W. K., "Meteorological reports, papers, lectures by;

college items, and personal items concerning him," *The Industrialist*, Kansas State Agricultural College, Manhattan, Kansas, Vols. 1–5 (1875–80).

KEDZIE, W. K., "Reports, papers, lectures by; college items, and personal items concerning him," *The Nationalist*, Manhattan, Kansas, Vols. 3–6 (1874–76).

WALTERS, J. D., "History of the Kansas State Agricultural College," Printing Department, Kansas State Agricultural College, 1909.

WILLARD, J. T., "History of Kansas State College of Agriculture and Applied Science," Kansas State College Press, Manhattan, Kansas, 1940.

MAKING WATER GAS BY CRACKING METHANOL

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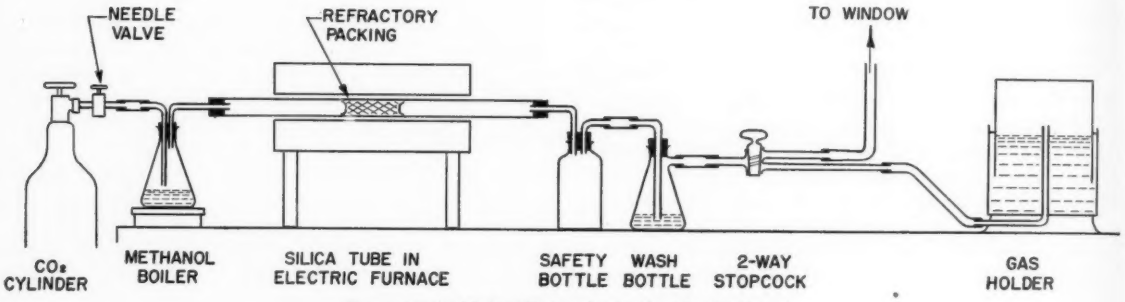


Apparatus for Making Water Gas by Cracking Methanol

IT IS perhaps not generally known that methanol vapor decomposes very readily at about 1000°C., without the use of a catalyst, into carbon monoxide and hydrogen. The process is simple enough to be done by students with only ordinary supervision, and requires no special equipment. The operation has been part of our laboratory work in industrial chemistry for several years, and serves a double purpose—to illustrate the industrially important "cracking" operation, and to make water gas for practice analyses with a gas analyzer.

We use a carbon combustion furnace, complete with its fused-silica tube. We put in this tube, at the hottest part, about three inches of some refractory material, in granular form, held in place by two pieces of nichrome screen wedged in.

The methanol boiler is a conical flask, with both inlet and outlet tubes, heated by an electric hot plate. The outlet tube of the boiler is connected to the inlet end of the silica tube. At the outlet of the silica tube, there is a safety bottle, followed by a water-scrubbing bottle to remove any undecomposed methanol. Then comes a two-way stopcock, one arm of which is connected to a miniature gas holder of about one gallon capacity. The other arm is vented outdoors through a long tube going out of a window.

Formation of explosive mixtures is avoided by flushing out the air with carbon dioxide or nitrogen from a cylinder, when starting up, and flushing out the water gas with the same inert gas in shutting down. This is the reason for the inlet tube on the methanol boiler.

After the silica tube is up to temperature, the air is flushed out, and the methanol started boiling. The first product gas, being contaminated with inert gas, is allowed to escape outdoors. When it is believed that the inert gas has all been swept out, a holderful is collected. The gas is then vented again, and the inert gas turned on again as the heat is turned off under the boiler. Soon after the methanol stops boiling, the flushing is stopped and the apparatus can be dismantled.

There is perhaps a remote risk of carbon monoxide poisoning. Our students are warned of the symptoms and treatment; but after using the process for three years, no trouble has been encountered.

The product runs very close to the calculated composition—two-thirds hydrogen, one-third carbon monoxide, with a few tenths of a per cent of methane.

The only item of equipment that would not ordinarily be found in a reasonably well-equipped laboratory is the miniature gas holder. The author does not know whether these are obtainable; ours was built in our sheet-metal shop to the author's design.

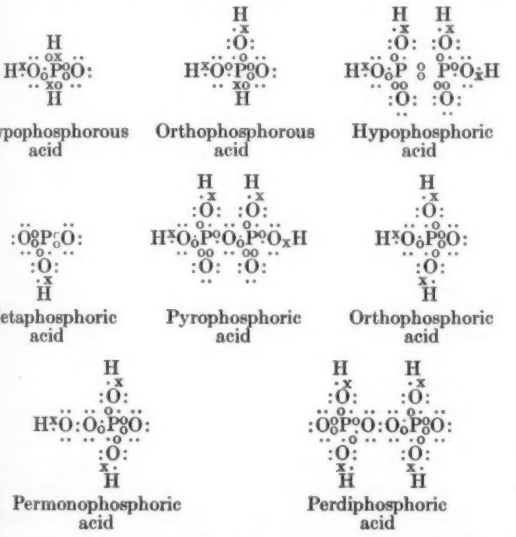
OXIDATION NUMBER IN AUTO-REDOX REACTIONS

LAWRENCE P. EBLIN
Ohio University, Athens, Ohio

THE value of the concept of oxidation number, sometimes called valence number, lies in its practical utility. In particular, a knowledge of oxidation state provides the means for finding out which elements are oxidized and which elements are reduced in redox reactions. Furthermore, it provides a means for balancing redox equations.

Most present-day textbooks carefully note that there is often no apparent relationship between oxidation number and the nature of the bonds by which atoms are united. Consider, for example, the following quotation from Jones' "Inorganic Chemistry":[1]

The structures assumed for the various acids of phosphorus are:



Hypophosphorous acid | Orthophosphorous acid | Hypophosphoric acid

Metaphosphoric acid | Pyrophosphoric acid | Orthophosphoric acid

Permonophosphoric acid | Perdiphosphoric acid

It will be noted that in each of these formulas the phosphorus atom is sharing all five of its outermost electrons, and that in each case, save in that of metaphosphoric acid, the phosphorus atom is surrounded by four other groups. The real valence of phosphorus is, therefore, in each instance five, while its coordination number is in each case four, save in the case of metaphosphoric acid in which it is three. The various oxidation numbers which may be calculated for phosphorus in these compounds are:

Hypophosphorous acid (H_3PO_2) + 1
Orthophosphorous acid (H_3PO_3) + 3
Hypophosphoric acid ($H_4P_2O_6$) + 4
Metaphosphoric acid (HPO_3) + 5
Pyrophosphoric acid ($H_4P_2O_7$) + 5
Orthophosphoric acid (H_3PO_4) + 5
Permonophosphoric acid (H_3PO_5) + 7
Perdiphosphoric acid ($H_4P_2O_8$) + 6

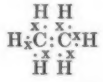
From the above structures, it is apparent that these numbers are imaginary, since they represent no real valence. Even so, however, they are useful in classifying the compounds of phosphorus and their reactions, and they are especially useful in balancing oxidation-reduction equations for such reactions in which they participate.

Sisler, Vanderwerf, and Davidson[2] point out that by the application of the conventional rules, we arrive at a different oxidation number for carbon in each of the following compounds:

$\overset{-4}{C}H_4$ $\quad$ $\overset{-2}{C}H_3Cl$ $\quad$ $\overset{0}{C}H_2Cl_2$ $\quad$ $\overset{+2}{C}HCl_3$ $\quad$ $\overset{+4}{C}Cl_4$

Thus, while the valence of carbon remains constant at 4, its oxidation state varies all the way from -4 in methane to $+4$ in carbon tetrachloride.

Some of the anomalies of oxidation numbers are thoroughly consistent with the fundamental rule that the oxidation number of any element in the free state is zero. For example, in ethane C_2H_6, the oxidation number of carbon is calculated to be -3. Considering the electronic formula for ethane,



it is apparent that the oxidation number of carbon is numerically equal to the sum of the covalent bonds exclusive of homatomic bonds. The result is that in the alkane series, C_nH_{2n+2}, the oxidation number of carbon varies from -4 in methane to -3 in ethane, $-2^2/_3$ in propane, $-2^1/_2$ in butane, and so on, approaching -2 as a limit.

Such "strange" oxidation numbers as $-2^2/_3$ are easily explained as averages. Thus, in propane, C_3H_8, each of the two terminal carbon atoms is bonded to three hydrogen atoms, and the oxidation number of each of these carbon atoms may be said to be -3 in the same sense that the oxidation number of each carbon atom in ethane is -3. Since the middle carbon atom of the propane molecule is bonded to only two hydrogen atoms, the oxidation number of this atom may likewise be regarded as -2. Since the sum of the three oxidation numbers is -8, the average is $-^8/_3$, or $-2^2/_3$. In this way we "explain" quite satisfactorily the oxidation number $-2^2/_3$ as an average.

Since in all alkanes the oxidation number of carbon is algebraically less than -2, the combustion of any alkane to give carbon dioxide, wherein the oxidation

[1] JONES, W. NORTON, "Inorganic Chemistry," The Blakiston Company, Philadelphia, 1947, pp. 374–5.

[2] SISLER, H. H., C. A. VANDERWERF, AND A. W. DAVIDSON, "General Chemistry, A Systematic Approach," The Macmillan Company, New York, 1949, p. 219.

number of carbon is +4, involves an algebraic increase in the oxidation number of carbon. Since oxidation is defined as an algebraic increase in oxidation number, it is gratifying to be able to say that the combustion of any alkane involves the oxidation of carbon.

Even if, as Jones contends, some oxidation numbers are "imaginary," the foregoing discussion shows that it is possible to explain many such oxidation numbers as averages. Even the oxidation number zero for the single carbon atom in CH_2Cl_2 can be interpreted as an average of +2 and −2.

Once it is agreed that the value of the oxidation number concept lies in its utility, then the measure of its value lies in its utilitarian reliability. In particular, the oxidation number concept is well justified if it facilitates the comprehension of redox reactions, or even if it merely facilitates the balancing of redox equations. In the reaction:

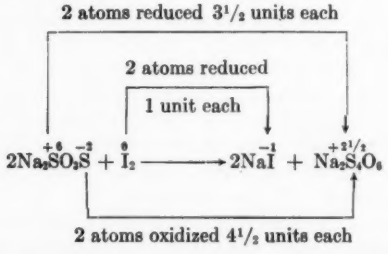
$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$$

the iodine is clearly reduced, and from this fact alone it would be inferred that the sulfur is oxidized. By the rules for determining oxidation number, the sulfur *is* oxidized, since the oxidation number of sulfur is increasing from +2 in the thiosulfate to $+2^1/_2$ in the tetrathionate. Furthermore, the assumption that the oxidation number of each sulfur atom increases $^1/_2$ unit makes it possible to balance the equation correctly by the oxidation number change method. Surely, the importance of the oxidation number concept lies in the fact that it "works" so well, even in situations where the oxidation numbers themselves do not seem to "make sense."

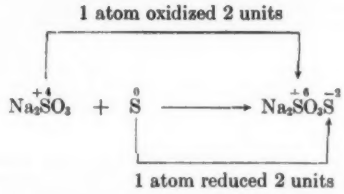
What "sense" is there in the statement that the oxidation number of sulfur in $Na_2S_2O_3$ is +2? The only possible meaning in it is that +2 is an average of the "real" oxidation numbers of the two sulfur atoms. In the words of Sisler and co-authors:[3]

> From the electronic formula and by analogy with the sulfate ion, this [the valence +2 for sulfur] may be interpreted as an average between +6 for the central sulfur atom and −2 for the coordinated sulfur atom.

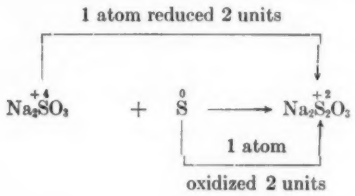
But if this is agreed to, then in the iodine-thiosulfate reaction, not only the iodine but part of the sulfur undergoes reduction:



Similarly, in the combination of sulfur with sulfites, it is really the sulfite sulfur that is oxidized. For this atom becomes, in the thiosulfate, the central atom previously referred to as having the oxidation number +6. In other words, the sulfite sulfur has been oxidized from +4 to +6:



On the other hand, if one ignores the question of structure and simply gives sulfur the apparent oxidation number +2 in thiosulfates, the sulfite sulfur in this reaction will be said to undergo reduction from +4 to +2:



The elementary sulfur will be *oxidized* if its valence number changes from 0 to +2, but it will be *reduced* if its valence number changes from 0 to −2.

A similar problem is posed in connection with the decomposition of the hypothetical thiosulfuric acid:

$$H_2S_2O_3 \rightarrow H_2O + SO_2 + S$$

Is the liberated sulfur the product of oxidation or of reduction? The answer depends on the oxidation state from which it is assumed to have come. If it has come from the oxidation state +2, it has been reduced; if it has come from the oxidation state −2, it has been oxidized.

Earlier in this discussion, it has been made quite apparent that it is the *average* oxidation number that is customarily referred to by the term oxidation number. There are certain instances, however, in which this is never done. For example, the formula for ammonium nitrate is usually written NH_4NO_3, and this clearly implies the oxidation state −3 for one of the nitrogen atoms and +5 for the other. If it is good chemical etiquette to represent sodium thiosulfate as $Na_2S_2O_3$, perhaps it could be permitted to write the formula for ammonium nitrate $N_2H_4O_3$. If we do so, the oxidation number of nitrogen appears to be +1. It cannot be said that this is really "wrong," for +1 is simply the average of −3 and +5.

If one is permitted to write the equation for the decomposition of ammonium nitrate in the following manner:

$$\overset{+1}{N_2}H_4O_3 \rightarrow \overset{+1}{N_2}O + H_2O$$

the interesting implication results that the reaction is *not* a redox reaction! Similarly, the decomposition of

[3] *Loc. cit.*, p. 481.

ammonium nitrite may be made to appear *not* a redox reaction:

$$\overset{0}{N_2}H_4O_2 \rightarrow \overset{0}{N_2} + 2H_2O$$

A slightly more complicated example is the reaction between mercuric chloride and sodium thiosulfate when the two compounds are present in solution in the ratio 1:1.

$$HgCl_2 + Na_2\overset{+2}{S_2}O_3 + H_2O \rightarrow 2NaCl + \overset{-2}{HgS} + H_2\overset{+6}{SO_4}$$

As formulated above, this appears to be a redox reaction, involving the oxidation of one sulfur atom, and the reduction of the other one by an equal amount. If, however, the "real" oxidation numbers of the individual sulfur atoms are considered, the reaction appears to involve no change in oxidation number, whatsoever. Is this a redox reaction or is it not a redox reaction? Apparently, if this one is considered to be a redox reaction, then the decomposition of ammonium nitrate must be judged not to be a redox reaction. It would hardly be consistent to think in terms of average oxidation number in the one example and not do so in the other.

Other examples could be cited that present the same dilemma as is posed in the foregoing cases. All of them are reactions of the type which may conveniently be called auto-redoxion. There is some confusion apparent in textbooks over the use of the two terms, auto-redoxion and internal redoxion. For the sake of clarity, the writer suggests the adoption of the following usage: *Auto-redoxion* should be used to designate any redox reaction wherein one atom of an element oxidizes another atom of the same element. *Internal redoxion* should be used to describe a redox reaction wherein the atom that is oxidized and the atom that is reduced are within the same compound; if the two atoms in question are atoms of the same element, we have a case of *internal auto-redoxion.*

Examples of auto-redoxion:

$$Na_2SO_3 + S \rightarrow Na_2S_2O_3$$
$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

Examples of internal redoxion:

$$2HgO \rightarrow 2Hg + O_2$$
$$2KClO_3 \rightarrow 2KCl + 3O_2$$

Examples of internal auto-redoxion:

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$
$$3Cl_2 + 6KOH \rightarrow 5KCl + KClO_3 + 3H_2O$$

As stated above, the apparent dilemma over which atom is oxidized and which atom is reduced arises only in cases involving auto-redoxion. Such cases always involve, either as a reactant or as a product, a compound wherein one atom of an element has a positive oxidation number and the other atom a negative oxidation number. The writer is convinced, on the basis of the foregoing considerations, that it is advisable to dispense with the concept of average oxidation number in such instances. For it borders on absurdity to contend, for example, that the liberation of elementary nitrogen by the decomposition of ammonium nitrite is not a case of redoxion. Having made our decision, then for the sake of consistency we must avoid such practices as designating the oxidation number of sulfur in thiosulfates to be +2.

Applying this recommendation to peroxy acids, the writer finally must register his objection to the oxidation number which Jones assigns to phosphorus in the acids having the formulas H_3PO_5 and $H_4P_2O_8$. Since these compounds contain the peroxide linkage, it is meaningless to deduce an oxidation number for phosphorus on the assumption that the peroxide linkage is absent. Since hydrogen peroxide has the formula H_2O_2, the oxidation number of oxygen therein is −1, *i. e., the peroxy radical has the oxidation number −2.* Writing the formula for H_3PO_5 in a pseudo-structural manner, $H_3PO_3O_2$, we can readily infer an oxidation number of +5 for phosphorus:

$$\overset{+3}{H_3}\ \overset{+5}{P}\ \overset{-6}{O_3}\ \overset{-2}{O_2}$$

Similarly, the oxidation number of phosphorus in $H_4P_2O_8$ is +5:

$$\overset{+4}{H_4}\ \overset{+10}{P_2}\ \overset{-12}{O_6}\ \overset{-2}{O_2}$$

By the same reasoning, the writer concludes that the oxidation number of sulfur in H_2SO_5 and $H_2S_2O_8$ is +6, rather than +8 and +7, respectively. This puts him in agreement with Sisler, Vanderwerf, and Davidson, who write:[4]

> It should be noted that the oxidation state of sulfur in the peroxysulfates, just as in sulfates and pyrosulfates, is +6. The oxidizing action of peroxysulfates involves no change in the oxidation state of sulfur, but rather a change of the "peroxy" oxygen atoms from −1 to −2.

It wil' be noted that Sisler and co-authors use the prefix *peroxy-* in preference to *per-* in referring to acids and salts containing the peroxy group. This should be made standard practice to avoid confusion with perchlorates, permanganates, etc., which are compounds that do not contain the peroxy group.

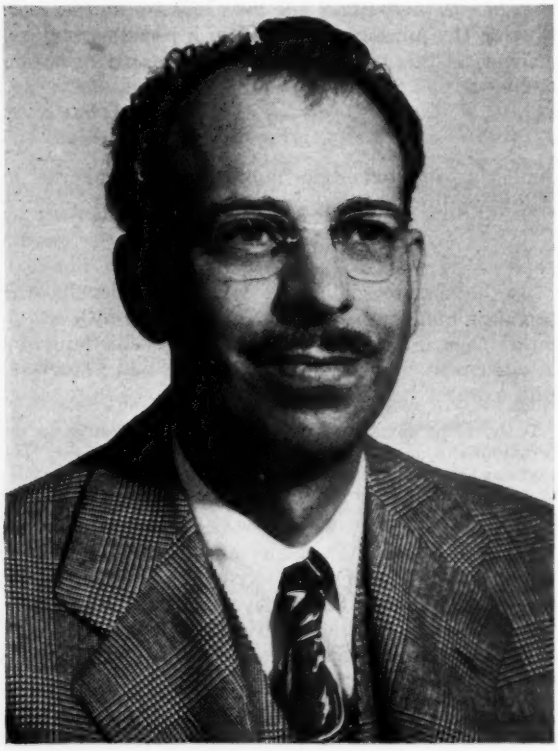
[4] *Loc. cit.*, p. 481.

Proceedings of the

PACIFIC SOUTHWEST ASSOCIATION OF CHEMISTRY TEACHERS

OFFICERS FOR 1951

THE Pacific Southwest Association of Chemistry Teachers elected the following officers for the year 1951: L. Reed Brantley, President; Blanche Bobbitt, Secretary; Richard Wistar, Treasurer. These succeed the first officers of this Association, Arthur Furst, Valerie Phillips, and Claude Merzbacher, who held the offices of President, Secretary, and Treasurer during 1950. The Vice-Presidents of the Association are the Chairmen of the local divisions, whose elections have been previously announced, J. Robert Harper for the Southern California Section and H. Murray Clark for the Northern California Section.



L. Reed Brantley

L. Reed Brantley, new President of the Pacific Southwest Association of Chemistry Teachers, is the Chairman of the Chemistry Department at Occidental College, Los Angeles. Dr. Brantley has been at Occidental since he obtained his Ph.D. in 1930 from the California Institute of Technology, where he did his graduate work under A. A. Noyes and A. O. Beckman. Since then his research interests have ranged from high temperature equilibrium to fluorine chemistry and the adhesion of organic coatings to nonferrous metal surfaces.

In addition to his teaching and administrational duties, Dr. Brantley is also an active member of many professional organizations, such as the American Association for the Advancement of Science, Sigma Xi, and the Electrochemical Society. He is a Pacific District Councilor of Alpha Chi Sigma and past president of its Los Angeles Chapter. He served as the Chairman of the Southern California Section of the American Chemical Society in 1947–48, and is still a Councillor for this Section. Recently he was appointed to the A. C. S. Standing Committee on Chemical Education by President N. H. Furman.

From the beginning, Dr. Brantley has been closely connected with the Pacific Southwest Association of Chemistry Teachers. At the San Francisco A. C. S. Meeting in March, 1949, he took a prominent part in organizing the group called by Dr. Otto Smith for the purpose of initiating a chemistry teachers' association on the west coast. At that meeting he was made temporary chairman of the southwest group and given the responsibility of drawing up the constitution and bylaws for the new organization. For the accomplishment of this task, he formed committees among southern California teachers, and in November of 1949, presented the results of his work at the First Annual Meeting of the Association in San Francisco. During the following year, Dr. Brantley was Chairman of the Southern California Section and Vice-President of the Association.

Even while away on his sabbatical leave last semester, Dr. Brantley still found time to advance the interests of the PSACT. At Washington he stopped at the A. C. S. Office to give Secretary A. H. Emery an account of the growth of the Association. At Oberlin College he interviewed Dr. J. Arthur Campbell, Chairman of the Division of Chemical Education, about the relationship between the PSACT and that division. He visited Dr. Otto Smith at Oklahoma Agricultural and Mechanical College to discuss the progress of the Association with the man whose vision saw the need for such an organization.

Blanche G. Bobbitt, new Secretary of the PSACT, is the Supervisor of Science in the Senior High Education Division of the Los Angeles City School District. Dr Bobbitt obtained a Ph.D. in biochemistry in 1941 from

Blanche Bobbitt

the University of Southern California, where she worked on vitamins and liver glycogen changes. She taught chemistry and physics in Los Angeles high schools from 1927, with intermissions for graduate work, until her supervisory assignment in 1945.

In addition to being an active member of the American Chemical Society, the National Science Teachers Association, the Association of Physics Teachers, and the California State Council of Mathematics, Dr. Bobbitt belongs to Iota Sigma Phi, Phi Beta Kappa, Phi Kappa Phi, Sigma Xi, Phi Sigma, and Delta Kappa Gamma, all honorary societies representing high achievement in some field of intellectual endeavor. She has many publications in the fields of biochemistry and education; she is an abstractor for the *Biological Abstracts*, and the author of some timely booklets, "The S in UNESCO" and "Atomic Energy and You."

Dr. Bobbitt has also participated from the beginning in the activities of the Pacific Southwest Association of Chemistry Teachers. Before her election as the Association Secretary, she had been the Secretary of the Southern California Section since its foundation.

Richard Wistar, Treasurer of the PSACT for 1951, is Professor of Chemistry at Mills College in Oakland, California. He came to Mills College in 1939 immediately after obtaining his Ph.D. from Harvard University in the field of physical organic chemistry. His research interests are in reaction kinetics and the mechanism of organic reactions.

In 1949 Dr. Wistar was the Chairman of the California Section of the American Chemical Society, and shouldered the responsibility of the host section for the National Meeting in San Francisco that year.

Richard Wistar

Currently Dr. Wistar is organizing a review service of the audio-visual aids for chemistry teachers. It is to consist of reviews of films to be published in the JOURNAL OF CHEMICAL EDUCATION, which will aid the teacher in selecting and ordering useful films without waste of valuable time. It is of interest that this project grew out of a paper he gave at the First Annual Meeting of the PSACT on the need of critical evaluations of the individual chemical films.

GENERAL CHEMISTRY WORKSHOP

The Committee on College Teaching of the Division of Chemical Education of the American Chemical Society has announced the dates for the Second Annual Conference or Workshop on the Teaching of General College Chemistry. The sessions will be held on the campus of Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma, June 13–22.

More than 50 professors of General Chemistry from all parts of the United States were in attendance last year and more than a hundred are expected this year. Announcements are being mailed to heads of departments of chemistry, and the list of speakers who will speak to general group meetings will be announced soon.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

AUTORADIOGRAPHY AS A SCIENCE PROJECT

WILLIAM S. HUBER
Rhode Island School of Design, Providence, Rhode Island

THE discovery of radioactivity by Henri Becquerel (1896) has been described variously as being either the result of a fortuitous circumstance or as one of definite planning. Jean Becquerel, in a letter (*1*), states that his father quite intentionally subjected a photographic plate to uranium salts, having assumed that the fluorescence phenomena might be accompanied by a radiation similar to X-rays. Instead, he discovered radioactivity. Like other discoveries, the phenomenon might have been identified several years earlier had more fundamental knowledge been available. Moser, in 1842, observed the pseudo-photographic effect of some solid materials and Niepce de Saint Victor (1867) obtained the real radiographic effect with uranium salts as did Becquerel but attributed it to luminescence (*2*). In these and other experiments the only observations were that the photographic plates were darkened or fogged, and it was not until 1911 that Reinganum (*3*) found that alpha-particle emanations made distinct tracks in emulsions. Since then, especially within the last few years, a vast amount of research has been devoted to this branch of science, with the result that much has been added to our present-day knowledge of nucleonics by photographic track techniques.

However, although the contributions by workers in autoradiography have been extensive and profound, it is notable that the mechanics of the technique differ little from Becquerel's experiment. True, improvements in materials and instrumentation have accompanied the advancement in nuclear science. However, autoradiographs of really interesting types can be obtained and examined with no more than what Morrison (*4*) describes as the tools of the celebrated Bristol group (*8, 10*): " . . .a photographic plate, a microscope, and plenty of insight, patience, and skill, always the best of apparatus." Therefore, the exploration of some of the methods of autoradiography as a science project not only is feasible but it should be valuable since, if it does nothing more, it will make the emanation process more tangible.

As an outline of what can be undertaken, the first experiment might be similar to that done by Becquerel. Any reasonably active mineral, such as a specimen of pitchblende or carnotite, may be placed on a bare camera film. An orthochromatic sheet film or a glass lantern slide plate is recommended in preference to the more sensitive panchromatic emulsions since the latter must be handled in absolute darkness. (Even with considerable experience, the author occasionally finds that the gremlins have a way of moving things around in the dark!) When the film is developed a few days later, a blackened area will be visible and, if examined under a microscope, one will see an astronomical number of dark grains of silver. In all frankness, it is doubted if this sight will stir up any long-lasting enthusiasm in the student but the experiment will serve to orient him as well as being one "for the record."

A second experiment might be made by procuring a piece of polished, dendritic uraninite from a supply house and similarly exposing it. However, here it is recommended that the film should be an emulsion of the high-contrast type, such as Eastman Commercial Sheet, in order to record the dendrites clearly. Development should be done in Eastman D-8, D-11, or D-19 in order to enhance contrast. If the negative comes out well, a glossy contact or an enlarged print can be made. Blown up to 8 × 10 in., such an enlargement has the beauty of a salon print. (See Figure 1.)

When an atom of a radioactive element disintegrates, the emitted ray, *e. g.*, an alpha particle, has a range in air of from a few to several centimeters, depending upon its energy. If the disintegration occurs in an emulsion, the distance traveled is much less, of the order of $^1/_{2000}$ of the air range but even that is greater than the thickness of the emulsions used for cameras. Consequently, alpha particles originating within the emulsion, as occurs in the "loading" technique described later, may pass into the glass or film backing, or they may escape upwards. On the other hand, some of the trajectories will be horizontal, and only these will present

completed paths for observation. Further, to make an easily perceptible path, a sufficiently large concentration of silver halide grains must be present in the emulsion to afford a closely spaced series of activated grains for subsequent blackening by the developing process. Such a track or series is not ordinarily visible in the optical-type emulsion owing to the low halide content.

To meet these two requirements of emulsion thickness and halide concentration, the Ilford Company of England and the Eastman Kodak Company have developed special nuclear-track emulsions that are designed to meet various conditions and requirements. In general, they range in thickness from 10 to 200 microns and have a halide content of from 65 to 80 per cent. In contrast to these values, the optical type of emulsion is about 10 to 15 microns thick and has a halide content of about 20 per cent. Further, as an added convenience, the nuclear emulsions are coated on the regulation 1 × 3-in. microscope slide, thus permitting accurate manipulation with a mechanical stage. In speed, they approximate the common ortho film and can be processed in red light with safety. Nuclear track plates are available from the manufacturer or from the Heinicke Instrument Corporation, 315 Alexander St., Rochester, New York. This company also supplies a Nuclear Physics Teaching Kit, consisting of a manual and five exposed, processed, and labeled plates containing nuclear events. The Eastman Kodak Company, Rochester, New York, publishes a technical bulletin describing the various types of plates in detail.

Since these plates are designed to cope with the various energies of atomic particles, different types should be used to obtain optimum discrimination between the very light and the heavier particles as well as to record very long tracks passing through the emulsion at an angle. However, for the work described in this paper, the Eastman NTB 50-micron slide appears well suited since it records both alpha rays and protons very clearly, and electron and meson tracks fairly well.

To illustrate their use, a series of uranium acetate solutions of different concentrations is prepared and, using individual capillary-tipped droppers or a very thin stirring rod, small drops of each are spaced across a slide—under red light, of course. As a suggestion, the solutions may range from 10^{-2} to 10^{-5} molar. Parenthetically, since the slides record scratches readily, it is advisable to hold them by the edges. The slide is placed in a light-tight container to dry and react for 24 to 96 hours. It is developed in D-19 for 10 minutes without agitation, transferred to a 2 per cent glacial acetic acid stop-bath for half a minute or so and fixed in any of the usual baths or in a straight 30 per cent solution of sodium thiosulfate. The usual practice of fixing for twice the clearing time and washing for half an hour in running water should be observed. It is good policy to discard the developer after use to avoid subsequent radioactive contamination of other plates, and to avoid waste the slide may be developed in a Petri dish instead of a large photo tray. Since this

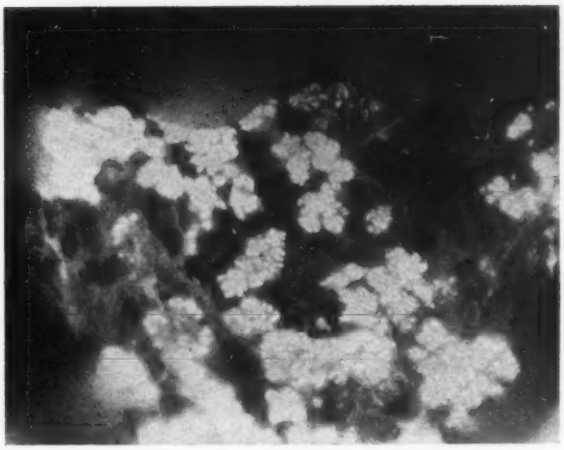


Figure 1. Polished Dendritic Uraninite

Exposed 73 hours on Eastman ortho sheet, 50 tungsten rating.

experiment is based on concentration a repetition based on time of activation suggests itself.

Instead of impregnating or "loading" the emulsion by allowing a solution to dry in it, as above, a very few tiny grains of carnotite and another mineral may be scattered at opposite ends of a slide. By this method, the tracks will be seen to radiate from the points of activity in contrast to displaying more even distribution in all levels of the emulsion. Also, the tracks will have a greater variation in lengths, due to the various elements present in secular equilibrium.

Reference to the uranium and thorium series suggests the use of a thorium salt as a comparison, the latter element being a more prolific begetter of the so-called "stars." When a slide is loaded with a thorium solution, the numerous stars are a result of the fact that the disintegration products of this element are shorter-lived than those of uranium (*5*).

Disintegration Products

Uranium Series			Thorium Series		
Product	*Radiation*	*Half-life*	*Product*	*Radiation*	*Half-life*
$_{86}Rn^{222}$	Alpha	3.82 days	$_{86}Rn^{220}$	Alpha	54.5 sec.
$_{84}Po^{218}$	Alpha	3.05 min.	$_{84}Po^{216}$	Alpha	0.158 sec.
$_{82}Pb^{214}$	Beta	26.8 min.	$_{82}Pb^{212}$	Beta	10.6 hr.
$_{83}Bi^{214}$	Beta	19.7 min.	$_{83}Bi^{212}$	Beta	60.5 min.
$_{84}Po^{214}$	Alpha	1.47×10^{-4} sec.	$_{84}Po^{212}$	Alpha	3×10^{-7} sec.

Therefore, if a solution of thorium nitrate is loaded into an emulsion, instead of producing numerous single alpha tracks many of the thorium atoms will have a greater opportunity to disintegrate in rapid sequence within the emulsion during the period of time between the moment of loading and the removal of the silver halide from the slide by fixing. Since the event is entirely dependent upon the factor of probability there will be both single and joined alpha stars, the latter varying from two to six prongs. The formation of a six-star is a rare event (*6*).

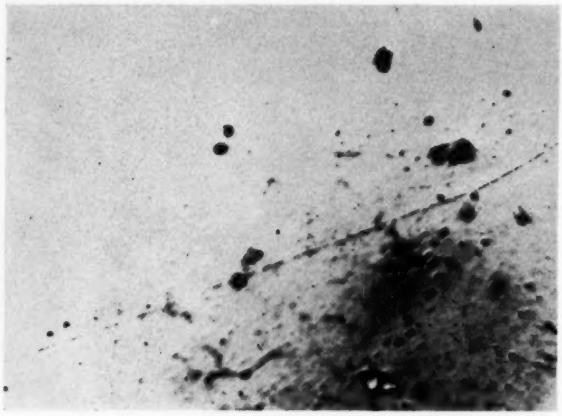


Figure 2. Proton Resulting from Cosmic Ray, Showing Scatter

Exposed 3 weeks on Eastman NTB 50-micron slide. Photographed on Eastman commercial ortho, 12 tungsten rating at 430 × magnification.

Stars and other events also occur in nuclear-track plates that have had no radioactive material applied to them. To demonstrate this, one or two slides may be kept in the original package for several weeks and then developed. Such appearances of tracks in untreated nuclear plates are due to the presence of radioactive impurities in both the glass and the emulsion. Evidence that such impurities do occur in the glass arises from the frequent observation of a group of alpha tracks that appear to be directed toward a common point but yet do not meet. Only such parts of a track as pass through the emulsion will make a photographic record. Occasionally tracks that are thinner and somewhat longer than those due to alphas will be seen, and unless they definitely do not fall in the category of cosmic mesons they are due to protons that have been ejected from an atom in the emulsion. It will be noticed particularly that at one end of these the grains appear less dark and more separated than at the other end. Also the heavier end may exhibit a slight bend. The reason for the first change (that of intensity) is the high initial speed of the proton, which traveled too rapidly to activate the silver halide strongly. As it passes through the emulsion its velocity decreases and there is a greater opportunity to activate the grains, thus rendering them more susceptible to development. The same loss of energy accounts for the bend or "scattering," since the proton then is more subject to repulsion by other atomic nuclei.

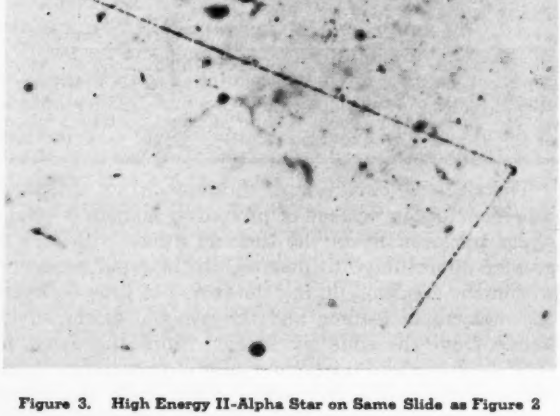


Figure 3. High Energy II-Alpha Star on Same Slide as Figure 2

The electron is no less ubiquitous in nuclear emulsions than elsewhere but its track is difficult to recognize in the type of plates thus far described. They are the lightest of all particulate radiations and they lose energy quickly. Therefore, their tracks are short and faint, appearing as tiny curlicues here and there in the emulsion or sprouting from an alpha star-prong. Webb gives a simple and interesting method (*7*) of producing them more abundantly by exposing a wrapped slide to X-rays of 50 to 200 kv.

Space does not permit describing all the experiments possible in this challenging project and for those interested there is no better source of inspiration than H. Yagoda's book, "Radioactive Measurements with Nuclear Emulsions" (*2*). However, a simple cosmic ray experiment should be included, for if there is anything in which the student will be interested it is these mysterious arrivals from the infinite spaces.

While a thicker emulsion may be used, the 50-micron NTB will serve and the combined methods of Camerini, Muirhead, Powell, and Ritson (*8*) and Perkins (*9*) followed. It is well known that the higher one goes from sea level, the greater are the number of cosmic events recorded. However, with stratosphere balloons, rockets, or mountains not always at hand, one still may try for and obtain them at sea level with absurdly simple arrangements. To do this, a packet of four nuclear plates in their original black wrapper is surrounded by blocks of paraffin (parowax slabs) cut to approximate size and sealed together by applying a hot stirring rod. This unit is wrapped in paraffined black and propped on end in a metal can having a light-tight cover. A one-pound tobacco can is satisfactory, with a few wads of newspaper as props. The can is placed on a table or hung up for three to six weeks in a sheltered place and the plates developed as usual when the period has elapsed. The plate yielding the events illustrated in Figures 2, 3, and 4 was one of a pair so suspended in a paper bag for three weeks under an open-porch roof.

The results will be a mixture of events in addition to those of cosmic origin. That is, there will be single alphas, small stars, and protons normally occurring from plate impurities. The cosmic events at sea level and with such brief exposures will be few, but one usually finds something sooner or later during the search. Thus, a long proton track with a greater-than-usual degree of scatter is not uncommon. If a

cosmic ray strikes a nucleus a large star may result and one should examine it carefully for prongs that are much, much lighter than the heavier, high-energy alpha prongs—an additional criterion of a nuclear disintegration due to cosmic influence. The two-prong star illustrated in Figure 3 actually has three other prongs that are too faint and too much out of planar coincidence to photograph. Lastly, using subdued light through the microscope, one searches carefully for meson tracks. These are so thin and indistinct that they may be overlooked if the light is too intense or if one scans the slide too hurriedly.

Much has yet to be learned concerning mesons and it is significant that a considerable portion of our present knowledge has been acquired through the use of nuclear-track emulsions. In general, according to a series of articles (*8*, *10*) by Powell, Occhialini, Lattes, Cüer, Muirhead, and others, the following facts seem to be certain:

(1) The term "meson" is applied to any particle having a mass intermediate between an electron and a proton.

(2) Two types of mesons, primary (π) and secondary (μ), differing in mass, have been identified.

(3) The majority of sea-level mesons are μ-mesons, formed by the decay of π-mesons in flight. This was concluded from the fact that while the ranges of π-mesons vary widely from less than 100 microns to about 1000 microns in the emulsion, the secondary events are far more constant, measuring from 565 to 666 microns.

(4) The π-mesons are either positive or negative.

(5) A positive primary meson decays, yielding a secondary meson. The latter appears to end in the emulsion without giving rise to further events.

(6) A negative primary meson can be captured by nuclei, and heavy particles are emitted, such as a proton or an alpha particle. When this occurs, the meson is classed as a σ-meson.

Thus, if a high-energy star is found, whether or not the meson is located, the star probably is due to a σ-meson. Again, in a sea-level plate, a long, thin event which has considerable scattering at one end, or even throughout its length, and which is joined to another straight-path event, may be found. Such a composite track can be identified as a positive primary meson giving rise to a secondary meson.

With respect to the examination of plates, a few suggestions may be offered. Scanning is best done at a magnification of 200–300, varying the intensity of illumination, and occasionally using colored filters to avoid eyestrain. Scanning must be done slowly lest the eye be unable to pick up what is sought. Certainly, a mechanical stage to facilitate systematic examination is a convenience if not a necessity, in order to enable one to return to an event for its subsequent photomicrography.

Photomicrography is done as in ordinary work and many systems of camera-and-microscope arrangement are possible, ranging from butting a folding camera up against the microscope, with the draw-tube horizontal, to the more professional attachments. Many students have devised efficient combinations using inexpensive miniature cameras. Anything will work if the event can be focused sharply in the camera. However, since the event is so small and in an otherwise practically clear field, there is an appalling absence of contrast. Therefore, it is essential that the film used in the camera should be one of the high-contrast type and that subsequent processing be done with one of the contrasty developers. D-19 is again recommended for both its contrast and its long life.

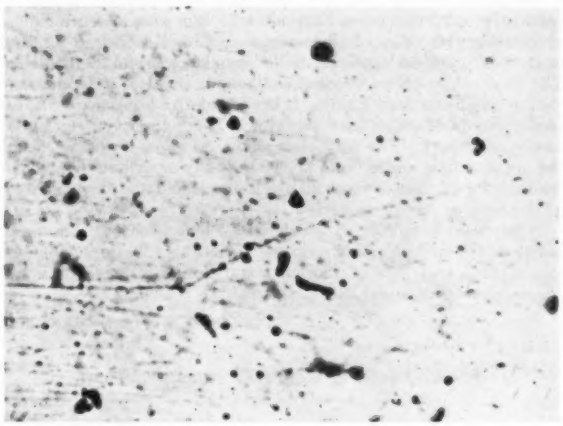


Figure 4. Primary-Secondary Meson on Same Slide as Figure 2

ACKNOWLEDGMENT

The author desires to express his sincere appreciation to Dr. Laurence S. Foster, Editor of the Report of the NEACT (*11*), for his assistance in the preparation of the manuscript, and to Mr. James Shanley, Class of 1953, Textile School of the Rhode Island School of Design, for exposing and processing the negative of Figure 1.

LITERATURE CITED

(1) Becquerel, J., *Nature*, **161**, 609 (1948).
(2) Yagoda, H., "Radioactive Measurements with Nuclear Emulsions," John Wiley and Sons, Inc., New York, 1949, p. 1.
(3) Yagoda, H., *ibid.*, p. 3.
(4) Yagoda, H., *ibid.*, p. 290.
(5) Friedlander, G., and J. W. Kennedy, "Introduction to Radiochemistry," John Wiley and Sons, Inc., New York, 1949, pp. 12, 13.
(6) Yagoda, H., *op. cit.*, p. 149.
(7) Webb, J. H., *Chemistry*, **22**, No. 6, 5 (1949).
(8) Camerini, U., H. Muirhead, C. F. Powell, and D. M. Ritson, *Nature*, **162**, 433 (1948).
(9) Perkins, D. H., *Nature*, **160**, 707 (1947).
(10) Occhialini, G. P. S., and C. F. Powell, *Nature*, **161**, 551 (1948).
(11) Foster, L. S., "Demonstrating Radioactivity by Autoradiography," J. Chem. Educ., **27**, 225 (1950).

Recent Books

CHEMISTRY AND YOU

B. Smith Hopkins, Professor of Chemistry Emeritus, University of Illinois; **Herbert R. Smith,** Head, Physical Science Department, Lake View High School, Chicago; **M. V. McGill,** Head Howe Military School, Howe, Indiana; and **G. M. Bradbury,** Instructor in Chemistry, Montclair High School, Montclair, New Jersey. Lyons and Carnahan, Chicago, 1950. ix + 772 pp. Illustrated. 15 × 23 cm.

"Chemistry and You" is a personal study of the subject of chemistry. At the same time none of the chemical principles or necessary theories of this science has been sacrificed for the numerous practical applications of chemistry in our daily lives. The book opens with a series of challenging pictures showing how chemistry affects daily living. It is a wonderful book to give boys and girls experience in good thinking. There are seventeen units nicely organized. The only change the reviewer would make in the organization would be to place the study of carbon last. The readings for pleasure and profit are well selected and the exercises offer ample material for review.

"Chemistry and You" is accompanied by a laboratory manual entitled "Chemistry and You in the Laboratory." It is compact and small in size (20.5 × 15.2 cm.) and contains 78 experiments. The laboratory manual is furnished with a teacher's key.

GRETA OPPE

Ball High School
Galveston, Texas

STRUCTURAL CHEMISTRY OF INORGANIC COMPOUNDS. VOLUME I

Walter Hückel, Professor of Pharmaceutical Chemistry, Tübingen University. Translated by **L. H. Long,** Lecturer in the Department of Chemistry, University College, Exeter. Elsevier Publishing Co., New York, 1950. xii + 437 pp. 50 figs. 17.5 × 26.5 cm. $9.

The author of this book has attempted "to furnish inorganic chemistry with that which organic chemistry has long possessed as a basis for its systematization, namely, a structural and constitutional theory in one embracing representation." This is a difficult task, for the structure of inorganic atoms is much more complex than that of the atoms commonly found in organic chemicals, and the nature of chemical binding in inorganic molecules and crystals is many times more varied than that exhibited by the compounds of carbon. Perhaps Dr. Hückel has not completely achieved this ambitious goal, but he has written an excellent book on inorganic chemistry.

Chapter I consists of an outline of the development of our ideas of the nature of matter and of valence. This is philosophical in nature and is well done, but it has little connection with the remainder of the book. In Chapter II the basis of systematization is laid down. It is pointed out that inorganic compounds may be classified as volatile and nonvolatile, and the latter are further divided into those which are soluble and those which are insoluble. Since these physical properties are not dependent upon the nature of the atoms in the material but upon the nature of the binding forces between them, the ultimate systemization is based on the homopolar bond, the heteropolar bond, and the postulates of the coordination theory. The discussion of the latter (Chapter III, 142 pages) is splendid, and includes several topics which are not adequately discussed in most books on inorganic chemistry—dinuclear and polynuclear compounds, the polyacids, isopoly bases, and the structure of the metaphosphates and soluble silicates.

Chapter IV (The Periodic System and the Structure of Atoms) is concerned largely with the spectral and magnetic evidence upon which our modern theories of atomic structure depend. Chapter V is devoted to brief discussions of the chief physical methods used in studying inorganic structures—X-ray analysis, conductivity measurements, dipole moment measurements, light absorption and emission, the Raman effect, and magnetic measurements. In Chapter VI, the author returns to a discussion of the chemical bond, which is here taken up from a different point of view than in Chapter II.

Volume II, which has not yet appeared in the English translation, will discuss Volatility of Inorganic Substances, Crystal Chemistry, Silicates and Glasses, Metals and Alloys, and Inorganic Chemical Reactions. The usefulness of the first volume will be greatly increased when the second volume appears, because Volume I contains many references to Volume II, and the index to both appears in Volume II.

The translator has attempted to adhere closely to the style of the original author, with the result that the sentence structure is sometimes clumsy and difficult to read. The proofreading was not carefully done, and many minor mistakes appear. None of these, however, will cause serious trouble. On the whole, the book is excellent, and is a distinct contribution to the literature of inorganic chemistry.

JONN C. BAILAR, JR.

University of Illinois
Urbana, Illinois

THE FRICTION AND LUBRICATION OF SOLIDS

F. P. Bowden and **D. Tabor,** Department of Physical Chemistry, Cambridge University, England. Oxford University Press, London, 1950. xii + 337 pp. 114 figs. 45 tables. 16 × 24.5 cm. $7.

This book is in the International Series of Monographs on Physics. "It describes an experimental study of the physical and, to a less extent, of the chemical processes that occur during the sliding of solids, particularly metals, and an investigation into the mechanism of friction and boundary lubrication. It is not a general textbook, since it deals almost entirely with experimental researches carried out by the writers and their collaborators and colleagues."

With the limitations admitted in the preface, the book is an excellent presentation of this specific subject.

KENNETH A. KOBE

University of Texas
Austin, Texas

INTRODUCTORY NUCLEAR PHYSICS

David Halliday, University of Pittsburgh. John Wiley and Sons, New York, 1950. ix + 558 pp. 279 figs. 69 tables. 14.5 × 22 cm. $6.50.

The preparation of an up-to-date book on all phases of nuclear physics is an ambitious undertaking. The author of this volume has been markedly successful in covering the wide range of subject matter and still maintaining it in compact readable form. To accomplish this he has eliminated a great deal of older work which has been superseded and has reduced mathematical development to a minimum.

A thorough understanding of modern nuclear theory demands some knowledge of quantum mechanics, and while certain of the concepts and equations are used in this book a great deal of infor-

mation and insight into nuclear processes can be obtained by those who do not have this preparation. The book is intended as a general nuclear physics textbook on a starting graduate level. The emphasis throughout is on experimental results, while theory is interwoven to correlate the observations and does not in general attempt to go beyond them.

The book is organized into 13 chapters each of which contains material printed in small type which can be ignored without interrupting the continuity of the subject. Each chapter is followed by a list of problems as an aid to those who wish to use the book for instruction.

The important underlying feature of this book is its obvious direct contact with current original literature. The reader will find discussions of the new developments of nuclear physics, of which there are many, in addition to the nuclear chain reaction. As examples, summaries are provided of the complex relationships of the different mesons and the current status of cosmic ray research, and new experimental methods such as neutron diffraction and microwave spectroscopy are described. In addition, most of the new instruments and machines of nuclear physics are diagramed and explained. For those who wish to go beyond the material given in the book a generous number of recent literature references are given, particularly to work which has not yet found its way into books.

A spot check through the book yielded a sprinkling of minor errors, most of them probably typographical, but the incidence seems to be smaller than that of most comparable books in first edition. Any particular research worker in nuclear physics might find that he would describe his field in more detail or with change in nuance, but in this reviewer's opinion the author has maintained a good perspective. The volume can be recommended both to students of the nuclear sciences and those with a more casual interest in the field as a faithful and lucid description of experimental nuclear physics today.

I. PERLMAN

University of California
Berkeley, California

• AN EIGHTEENTH CENTURY LECTURESHIP IN CHEMISTRY

Edited by *Andrew Kent*. Jackson, Son and Co., Glasgow, 1950. xv + 233 pp. 18 plates. 14 × 22 cm. 21/–.

In 1947 the University of Glasgow celebrated the two-hundredth anniversary of the founding of its first lectureship in chemistry. The first incumbent was William Cullen, his successor was Joseph Black, and the chair, which became a Regius Professorship with Thomas Thomson in 1818, has continued until the present day. As part of the celebration, four addresses were presented, dealing with Cullen, Black, the industrial development of Scotland during the Cullen-Black period, and Glasgow chemistry in the twentieth century. Subsequently these addresses were supplemented by a number of additional essays to make up the present book.

Although in a sense the book is the history of a single university, it is actully far more. It is as much the story of chemistry in the University of Edinburgh as of Glasgow, for the faculty of Edinburgh was drawn almost entirely from Glasgow in the eighteenth century. Between the two universities, most of the chemical developments of Scotland were covered. At this period Scotland was one of the leading centers of chemical education of the world. Particularly did students from colonial America come to study with Cullen and Black. The pioneering work of Rush in Philadelphia and Maclean at Princeton reflects the training they received in Scotland. Watt invented his steam engine at Glasgow, and many of the founders of English chemical industries were educated there.

All of these aspects of Scottish chemistry are treated in the brief but authoritative essays presented in this volume. Biographical sketches of the leading chemists of the period, Irvine, Robison, Hope, Cleghorn, and Thomson, supplement the fuller treatment of Cullen and Black. The physical setting, Glasgow and its University, are described, and the chemical background, stemming largely from Boerhaave and reflecting the main trends of a period when the doctrine of phlogiston was giving way to the chemistry of Lavoisier, is well discussed. The essay on "Phlogiston, Caloric, and Heat" is particularly illuminating in revealing the type of thinking which prevailed among chemists of that time. The industrial development of Scotland is described, and the story of Glasgow chemistry is carried down to modern times in the final essay. There is a short article by T. S. Patterson which makes some very pungent comments on modern methods of teaching chemistry, in contrast to the inductive method used by Black.

It can thus be seen that the book contains material which should appeal to almost every taste. In spite of the number of topics discussed, however, there is a unity of treatment which makes it a pleasure to read the book through. It recreates the informal spirit of the time, when students might throw a handful of dried peas at the professor, but it also recreates a period of intellectual ferment when chemistry was undergoing its most drastic change. There are few who will not find stimulation and profit in reading this volume.

HENRY M. LEICESTER

College of Physicians and Surgeons
San Francisco, California

• ELEMENTS OF FRACTIONAL DISTILLATION

C. S. Robinson and E. R. Gilliland, Professors of Chemical Engineering, Massachusetts Institute of Technology. Revised and rewritten by E. R. Gilliland. Fourth edition. McGraw-Hill Book Co., New York, 1950. ix + 492 pp. Illustrated. 16 × 23.5 cm. $7.

The fourth edition of "Elements of Fractional Distillation" has been entirely rewritten by Professor Gilliland, who has graduated the volume from the publishers International Chemical Series to the Chemical Engineering Series. Most of the chapters are new and those in the third edition (1939) dealing with special technologies have been discarded in favor of fundamental methods of design.

The first section of four chapters (100 pages) is entirely new. It deals with the determination of vapor-liquid equilibria, presentation of these data, and the calculation of equilibria. For the latter calculations, the use of the Duhem-Margules and Van Laar equations is illustrated. The following four chapters (113 pages) present simple distillation and rectification of binary solutions. The main emphasis is placed on the Sorel calculation and McCabe-Thiele graphical methods. The Ponchon enthalpy-concentration graphical method is treated rather briefly because of its limitation to binary solutions, although the general utility of this method in many chemical engineering calculations should warrant a more detailed treatment. A third section (156 pages) applies the previous methods to multicomponent solutions, using Sorel's method, and then shows the applicability of several alternate design methods. Extractive and azeotropic distillation methods are discussed and illustrated, as are batch and vacuum distillations. Esterification reactions are used to illustrate a brief chapter on simultaneous rectification and chemical reaction. A fourth section (109 pages) treats the problems of mechanical design of the fractionating column and auxiliary equipment. Finally, the performance of the column under operating conditions and plate efficiencies is discussed.

Although this book is the only modern text in English devoted to distillation, its title of "Elements" indicates that certain benefits and limitations are to be expected. Because all discussion begins with the fundamentals anyone with a good training in physical chemistry can master the book. For the chemical engineer with a bachelor's degree there will be a review of principles previously learned before progressing to new material. But this also is one of the limitations. The book does not discuss many of the newer and specialized methods that have appeared in the literature in the last few years, particularly for complex petroleum

fractions. The same can be said of column design methods. Hence, those expecting a review and summary of recent literature in the field will be disappointed.

It is peculiar that, after the A. I. Ch. E., A. S. A., and A. C. S. have set up certain standard symbols and notation a text in a chemical engineering series would fail to follow these standards. The consistent use of *mol* rather than *mole* is probably due to the desire to use the old illustrations rather than make new ones. Others apparent are μ for z (compressibiltiy), O for L (liquid flow in column), and others. The abundant references to M. I. T. theses and 10.45 notes which are not available to the nonresident of Cambridge could undoubtedly be replaced by journal references that would be of greater general value. Many of the journal references should be modernized; thus, instead of referring to Othmer's article in 1928 the 1948 reference should be used, as it refers to all of his previous papers in the field of vapor-liquid equilibrium.

Because this book is well-written and does cover excellently the field of distillation, it will be used widely as an advanced text and as a reference book.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● CHEMICAL CONSTITUTION AND BIOLOGICAL ACTIVITY

W. A. Sexton, **Imperial Chemical Industries, Ltd., Manchester, England. D. Van Nostrand Co., New York, 1950. xxi + 412 pp. 36 figs. 57 tables. 15.5 × 25.5 cm. $10.**

THE relation between chemical constitution and biological activity is of intense interest to workers in both the basic and applied sciences, and it is not surprising that the point of emphasis will be different for the two groups of investigators. It is the reviewer's opinion that the present monograph is more likely to appeal to those primarily interested in application rather than in basic principles. It may be noted that the author's implied goal is "the design of physiologically active molecules." In the introduction the author has provided an interesting historical account of the development of synthetic organic medicinals and of the premises behind this development. The treatment of this topic indicates an awareness as to present status and problems and as to what is fact and hypothesis. The general tone is somewhat optimistic.

The monograph can be considered to be composed of three parts; the first, Chapters I to V inclusive, is an account of what may be termed the chemistry of the probable *in situ* reactants, or matrix elements, and of the general nature of the reactions of these substances with diffusible reactants. The first chapter contains a very brief account of the current ideas relative to the structure of the proteins, nucleic acids, and polysaccharides. It is not apparent why the lipids are ignored. It is the reviewer's opinion that the section devoted to enzyme action could be substantially improved by adopting a more quantitative attitude. A reader familiar with the concepts of enzyme chemistry may be annoyed by the terminology employed in the second chapter entitled Chemical Mechanisms Determining Drug Activity. The use of "inhibition by neutralization" for the well established "irreversible inhibition" and the failure to clearly distinguish between the various types of reversible interactions cannot be commended. The examples given for irreversible inhibition are well chosen. In contrast, the reader cannot be certain that the examples given for "inhibition by competition" are truly illustrative since the only test applied is that of reversibility in very complex systems. In view of the author's use of conventional structural formulas to interpret physiological activity the reviewer would like to advance the proposition that the interpretation of some reactions of physiological interest may be beyond the scope of such models. A discussion of solubility phenomena, bond types, stereochemistry, surface chemistry, cellular permeability, and the kinetics of bacterial growth is given in Chapter III under the heading of Some Physico-Chemical Considerations. The treatment is far too brief and is generally superficial. The reviewer believes that the author's reluctance to adopt a more rigorous treatment, where such a treatment is possible, seriously detracts from the usefulness of his monograph. The last two chapters, of the first section are respectively titled Modification of Drugs By Living Organisms and Effects of Specific Chemical Groupings. The first of these two chapters is a reasonable account of the fate of organic compounds in living systems. Chapter V is based upon an analogy to dyestuff chemistry and elaborates on the proposition that biological activity can be explained, at least in part, on a functional group basis. The author is clearly aware of the limitations of this approach and the contents of this chapter, with but one or two exceptions, offer little that would not be surmised by anyone familiar with elementary organic chemistry.

The second part of the book, namely Chapters VI to XIII inclusive, is a series of essays on the chemistry and biological activity of those compounds which are commonly recognized as vitamins, or growth factors, and are known or presumed to be functional as prosthetic groups of enzyme systems. The topics covered are: nicotinamide, riboflavin, thiamine, *p*-aminobenzoic acid, pyridoxin, pantothenic acid, biotin, pyrimidines, purines, pterins, porphyrins, cholines, and quinones. The account given is adequate and is written in a reasonably critical vein. Many tables purporting to relate chemical structure and biological activity are given. The essay on *p*-aminobenzoic acid provides an interesting example of how a theory which was originally satisfying, because of a limited amount of data, has grown into a veritable monster by the introduction of numerous *ad hoc* hypotheses in order to explain additional observations.

The third and last part of the book is concerned with areas which, as the author points out, have been selected in a rather arbitrary manner. Chapter XIV contains a brief review of the more common antibiotics, Chapter XV a résumé of the chemistry of several of the hormones, and Chapter XVI a description of a number of bactericides and fungicides. The antiprotozoal drugs are discussed in Chapter XVII and the insecticides and anthelmentics in Chapter XVIII. The last three chapters, namely XIX to XXI, are devoted to cancer, plant growth regulators, and antigens and antibodies. In these chapters, as well as in the previous ones, no attempt has been made to present an exhaustive literature survey. At the end of each chapter a number of selected references are given, including some as recent as 1948.

The lack of success in relating chemical constitution to biological activity, except in very limited areas, is not due to any deficiency of this monograph, for it is doubtful that anyone could do a substantially better job at the present time. It is reasonably clear that a real understanding of the above topic is not even close and that the occasional success achieved in the development of a new "miracle drug" has contributed but little to the elaboration of basic principles.

CARL NIEMANN

CALIFORNIA INSTITUTE OF TECHNOLOGY
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● THE EFFECTS OF ATOMIC WEAPONS

Prepared under the direction of the Los Alamos Scientific Laboratory. Executive editor: *Samuel Glasstone.* McGraw-Hill Book Co., New York, 1950. x + 456 pp. Illustrated. 16 × 23.5 cm. $2.25.

A REVIEW of this book may conveniently start with the crude description of an atomic explosion as a bright light, gust of wind or, possibly, surge of water, and many "hot" atoms. Something like a third of the book is devoted to an account of the manner in which these phenomena develop. A second major portion of the text is concerned with predictions, and illustration by examples from the several bursts, of what happens to property and persons as a result. Finally there are discussions of possible defenses against atomic weapons.

The book is a joint effort of many persons, 24 being listed as

principal contributors, 14 as lesser ones, 48 as having reviewed the manuscript in whole or in part, and two as technical advisors to the staff of five editors. The list includes many eminent names and there is no question of the competence of the various contributors to write on their respective subjects. The coordination of all the material must have been a major effort and has been well done.

The discussions of the physical phenomena start with qualitative descriptions of the underlying causes which are followed by summaries of predicted and observed effects with only general indications of the theoretical or experimental basis. The scientific reader may wonder just how experimental points would look on many of the curves and a nontechnical reader would find much of the book heavy going. One can nevertheless hope that many will read this book rather than ones on astronomical collisions and flying saucers. The sections dealing with human and property damage are documented with photographs taken after the Japanese bombing and with a variety of statistics, all of which bear testimony to the intensive and extensive destruction. The discussion of protective and relief measures shows in a matter-of-fact way what formidable questions face the planners of atomic defenses.

The final effect of the book should be awesome for anyone not familiar at first hand with atomic weapons. A "nominal" bomb corresponding roughly to 20,000 tons of TNT is used as a basis for most of the discussion, the brightness of the ball of fire is expressed in "suns" as units, and distances of less than half a mile from such an explosion are found to be in such triple jeopardy from radiation, blast, and fire as not to be considered in any detail. One may perhaps find comfort of a sort in the comparison of the bomb with a third-rate earthquake, and in the conclusion that negligible effects on the weather are to be expected.

Whatever the limitations of the presentation arising from inadequate knowledge or omission of pertinent information may be, the book is a valuable summary of past experience with atomic bombs and of what may be expected to happen when one explodes.

ROBERT H. COLE

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● CHEMISTRY VISUALIZED AND APPLIED

Armand Joseph Courchaine, Instructor in Biological Chemistry, Hahnemann Medical College; and Science Instructor, Hahnemann Hospital School of Nursing, Philadelphia. Edited by *M. Cordelia Cowan.* G. P. Putnam's Sons, New York, 1950. xiv + 687 pp. 122 figs. 14 × 21.5 cm. $5.50.

There are three parts to this combined text and reference: Part I covers many important aspects of inorganic chemistry, Part II provides an introduction to organic chemistry, and Part III presents considerable information on biological chemistry. The book is intended for the use of students contemplating a career related to health and disease.

The quantity of detail which the author has been able to pack into a single volume is phenomenal and all of it consists of either basic chemical fact or the application of these facts to a study of physiology. The large number of unusual and interesting applications of chemistry to the field of medicine should make a strong appeal to those who will use this book.

The inorganic chemistry in the first twelve chapters is organized rather cleverly for ready assimilation. As early as page xii of the Practical Suggestions to the Student comes the warning that there are only four general types of chemical compounds—oxides, acids, bases, and salts; and, happily, only four general types of chemical change—synthesis, analysis, single replacement, and double replacement. In Chapter 2, Matter, there are lists of laws and of definitions. An example of a problem to determine formula from percentage composition is followed by an example of a problem to determine percentage composition from the formula. Each chapter begins with the clause: "From your daily reading, past study, and experience, do you recall:" and this clause is completed by a list of twenty or thirty alternative clauses such as: "What a molecule is? How many internationally known elements there are?"

Unfortunately, this kind of organization keeps the author so occupied that he has little time to follow the logical development of the great principles of chemistry. Even the structure of the atom is delivered dogmatically with no reference to the early experiments or to the periodic classification of the elements. Mendeleev and Moseley share less than a page between them. The suspicion arises that the author believes these students of health had better memorize the chemical facts that they will need in their business and leave the study of chemistry as a science to those with time and inclination to pursue it, a suspicion strengthened by a reading of the questions that appear at the end of the chapters.

In the second section, an introduction to organic chemistry, chemicals are grouped according to their medicinal value, thus disturbing much of the inherent logic of organic chemistry.

In the third section the author is clearly at his best, with page after page of interesting up-to-date information on biological chemistry.

Physicians, dentists, nurses, and others interested in the chemistry of health and disease have here an excellent reference book, but in using this book as a text, an instructor would need to show marked restraint.

BENTLEY EDWARDS

Chico State College
Chico, California

● QUAKERS IN SCIENCE AND INDUSTRY

Arthur Raistrick. Philosophical Library, Inc., New York, 1950. 361 pp. 16 plates. 14 × 22.5 cm. $6.

The author's thesis is that the persecution of the early Quakers almost inevitably drove them out of farming and into business and that their religious practices contributed heavily to their financial success. His examples are drawn exclusively from English Quakers of the period 1650 to 1800.

From the time of George Fox the Quakers have protested against the double standard of truth implied in the custom of taking oaths. As a consequence, they were branded as "subversive characters" and thrown into jail by the thousands. There is an appalling familiar ring to the story. They refused to pay tithes to the church and had their goods confiscated as a result. Most of them were originally farmers, but they shifted to various business occupations in which they were less dependent on horses, cows, implements, etc., which could so easily be taken from them.

The Quaker religion is a seven-day-a-week one, and the members had a compelling sense of social responsibility. They set the standards for fairness in business dealing, they had a deep concern for the welfare of their employees, and they were very conservative in their ventures. Numerous intermarriages united families in many different lines.

Among their most notable contributions to technology are the process for smelting iron ore with coke instead of charcoal, improvement in the purification of lead, and the making of the most accurate clocks and watches of the period. In the field of medicine, it was a group of liberal Quaker doctors who tested Jenner's technique of vaccination after the conservative Royal Society had turned a deaf ear to him. Various naturalists are mentioned, among them John Bartram, the only American Quaker included. The author shows a curious sense of proportion in giving almost the same space to his treatment of John Dalton and his contemporary chemist, William Allen.

This book shows the result of years of painstaking research. It is a valuable source book for details of industry and the social customs of the times.

RICHARD WISTAR

Mills College
Oakland, California

● DISTILLATION EQUILIBRIUM DATA

Ju Chin Chu, **Associate Professor of Chemical Engineering, Polytechnic Institute of Brooklyn;** ***R. Paul,*** **Teaching Fellow, Polytechnic Institute of Brooklyn;** ***R. J. Getty*** **and** ***L. F. Brennecke,*** **Chemical Engineers, Aluminum Ore Company. Reinhold Publishing Corporation, New York, 1950. v + 304 pp. 176 tables. 15 × 23 cm. $6.**

"Distillation Equilibrium Data" is a compilation of binary and ternary vapor-liquid equilibrium data which have appeared in the literature as of December, 1949. The attempt to include all available binary and ternary distillation data under one cover to serve as a ready reference for those working in the field of distillation is an excellent one. The systems are arranged alphabetically, based on the name of the more volatile component, and are numbered in order of their appearance. The index also presents an alphabetical listing of components and their system number and page.

While as a whole the book is a contribution to distillation literature, there are several defects. The bibliography as given has no cross references to page or system number. Names of a number of investigators listed in the bibliography are misspelled. In some cases the references are not to the original article in which the investigators reported their experimental data.

In spite of these discrepancies, the book will serve as a useful reference to those working in the field of distillation.

M. VAN WINKLE

University of Texas
Austin, Texas

● GENERAL CHEMISTRY FOR COLLEGES

Jelks Barksdale, **Alabama Polytechnic Institute. Longmans, Green and Company, New York, 1950. viii + 540 pp. 77 figs. 42 illustrations (halftones). 37 tables. 15 × 22 cm. $5.**

The recent texts in general chemistry for use in colleges have followed many different patterns. This text definitely sets a pattern of its own because of its frank and continual emphasis on the descriptive side of chemistry. Teachers who believe in this emphasis will probably be pleased with this text. Teachers who emphasize the principles of general chemistry and the continuous applications of these principles will find it worth while to examine this text in order to improve their own perspective of the entire subject matter of general chemistry.

The author has had both college teaching and industrial experience. The stated purpose of the author in offering this text is "the presentation of the essentials of general chemistry in a clear, simple manner so they can be learned and understood by students who are not chemistry majors. High school chemistry is not presupposed." The author stresses the arrangement of the text materials, which is based upon his own teaching and industrial experience. He furthermore emphasizes his opinion that "it is necessary to learn many facts of descriptive chemistry, simply by memorizing them," and that the student should possess a facile ability to write formulas and to write and balance chemical equations.

The writer of a text must assume the responsibility for clear, interesting, and simple writing, the reliability of all factual material, and for consistency in his treatment of textual materials. The author has erred in these respects to a greater extent than is usual for a first printing. There are many examples of hasty or careless writing and questionable statements of fact. Thus, on page 49 there appears the statement that hydrogen "is the lightest substance." The author meant no doubt to state that hydrogen is the lightest element. A statement on page 255 pertaining to phosphorus is true only for yellow phosphorus. Two equations on the top of page 242 are quite extraneous to the adjacent material in context. On page 45 one reads that there is a trace of hydrogen in the atmosphere "probably formed by electrolysis of atmospheric water caused by lighting." On page 35 there is a reference to Thompson and Astor, where the author should have referred to Thomson and Aston. On page 72 the figure to illustrate diffusion of gases should be vertical instead of horizontal.

The volume includes much more detailed descriptive material than most teachers of general chemistry can present in one year. The author, furthermore, has made use of many scientific ideas with no explanation. As a result, many passages can be interpreted by the teacher but they will be more or less meaningless to the beginning student with no high-school chemistry.

Teachers who like to teach chemistry as scientific method will be annoyed by a casual and dogmatic presentation of important scientific theories with no indication of the evidence which was responsible for the theories. Thus, on page 6 one reads, "Dalton, after careful study of the experimental evidence, came to the conclusion that all matter is composed of extremely small particles which cannot be further divided." None of the experimental evidence is cited. The kinetic theory is presented on page 62 as a finished picture and with little indication of its significance as a theory.

The publisher has done an excellent job of printing and binding. The total number of pages is considerably less than in many of the recent texts in general chemistry. Teachers who need a brief descriptive coverage of the material usually considered in the first-year's course in general chemistry should examine this book.

CONRAD E. RONNEBERG

Denison University
Granville, Ohio

● CHEMISTRY AND BIOLOGY OF PROTEINS

Felix Haurowitz, **Indiana University, Bloomington, Indiana. Academic Press, Inc., New York, 1950. xii + 374 pp. 52 figs. 16 × 23.5 cm. $5.50.**

Research in protein chemistry proceeds at so lively a pace that the authoritative treatise on proteins edited by C. L. A. Schmidt has become, in spite of its supplementary volume, out of date in some respects. Haurowitz has undertaken the difficult task of bringing the subject up to date, a task all the more difficult in that he has elected to present the subject in a relatively small volume. His choice of material, however, seems admirable. While emphasizing the newer knowledge about proteins, he gives clear résumés of the older and well-established facts.

A short introductory chapter on the role of proteins in biology is written more from the standpoint of the chemist than the biologist. There follow nine chapters which deal with the properties and methods of study of proteins and with the size, shape, and structure of protein molecules. Five chapters describe, respectively, the conjugated proteins, the enzymatic proteins, the proteins that are hormones, proteins of immunological interest, and toxic proteins.

The last two chapters dealing with protein synthesis in living things will be of especial interest to biochemists. While there are solid facts available for a foundation of the study of biosynthesis, the major part of the presentation reflects the incompleteness of our knowledge and is, accordingly, highly conjectural. But it is stimulating to the imagination and includes those theories which promise to be fruitful ones.

PHILIP H. MITCHELL

Brown University
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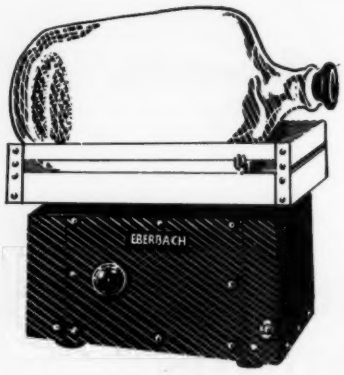

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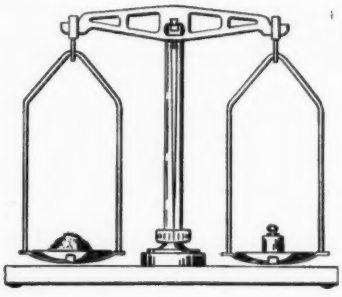

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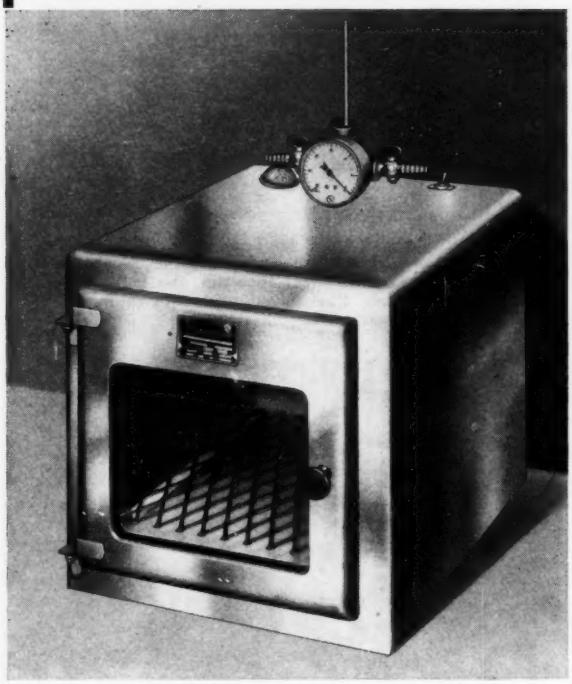

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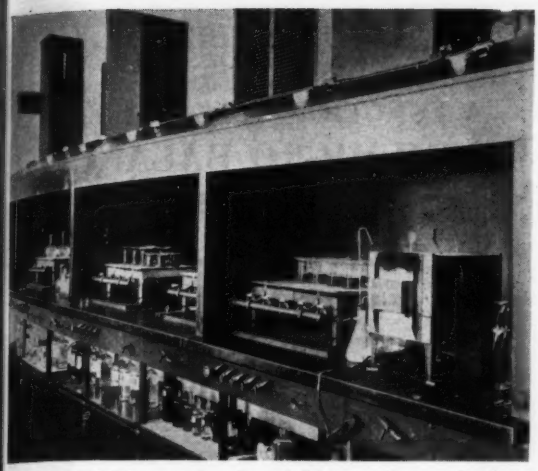

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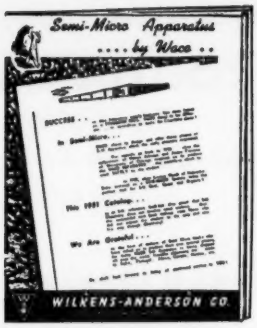

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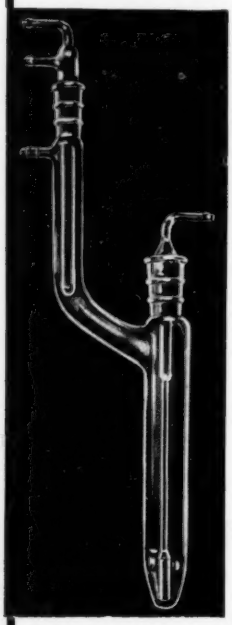

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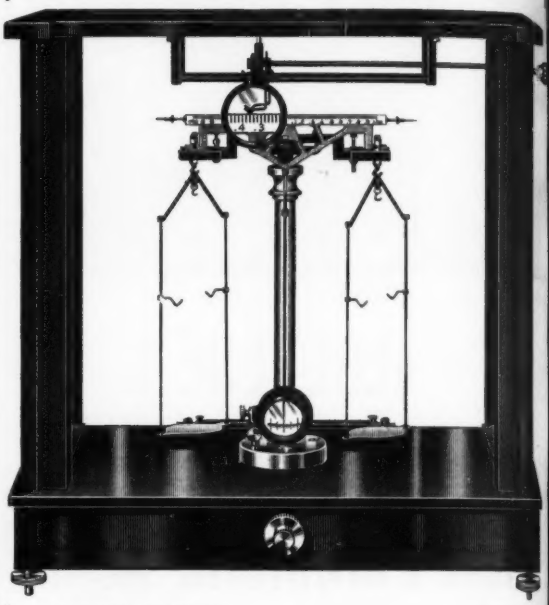

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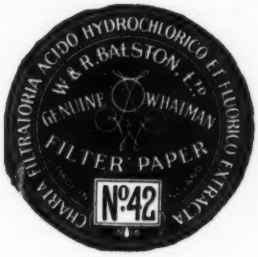

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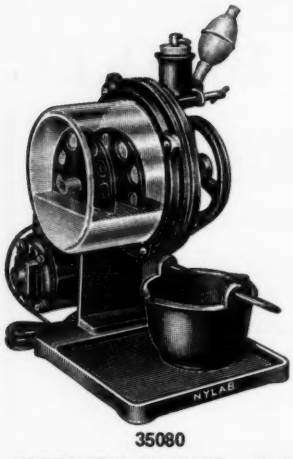

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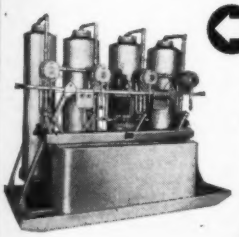

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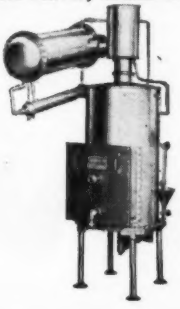

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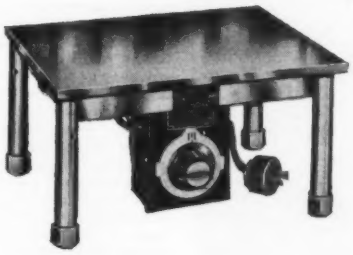

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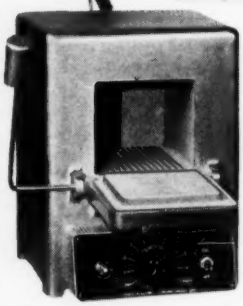

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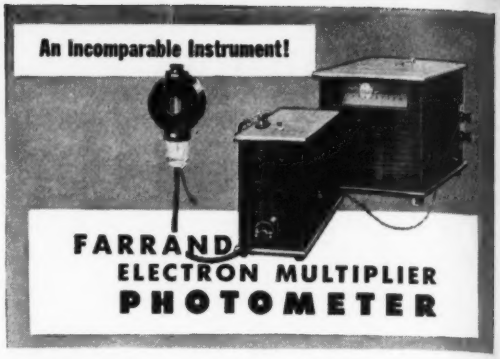

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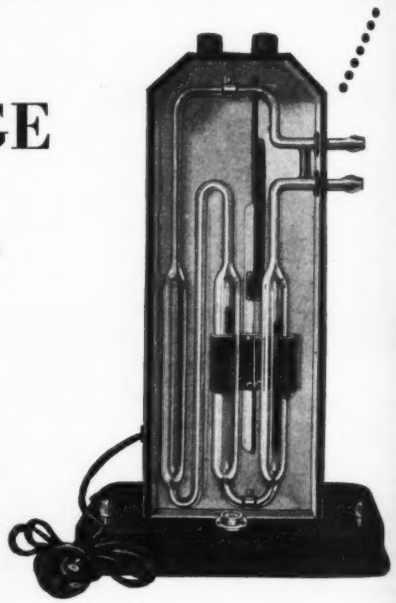

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Out of the Editor's Basket

DO Priority Rating for College and Industrial Laboratories

In a recent announcement, Kenneth Andersen, executive vice-president of the Scientific Apparatus Makers Association advised scientific laboratories of all types throughout the country to help avert a threatened shortage of laboratory instruments, apparatus, and supplies by making full use of National Production Authority Regulation 4 issued February 27, 1951.

Mr. Andersen urged purchasing agents of educational institutions, hospitals, research organizations, industrial research and control laboratories, and all others who purchase such supplies to obtain a copy of the regulation and to make use of its provisions when ordering maintenance, repair, and operating (MRO) supplies.

The order permits all institutions and businesses to purchase MRO supplies with a priority rating (DO-97) which "is on an equal basis with all other DO ratings" for the purchase of military supplies and equipment.

Apparatus and supply distributors need these DO ratings from their customers to pass along to the manufacturers who must have them to obtain critical raw materials and components.

Mr. Andersen pointed out that so many businesses are now authorized to use DO priorities under the new regulation that orders not so designated probably will be subject to all manner of delays.

Copies of the order can be obtained from the NPA in Washington and from the various field offices of the Department of Commerce.

The order also permits purchase with the DO priority rating of minor capital equipment items with a maximum value of $750 each.

Permafil

A material which remains liquid as long as a stream of air bubbles through it, but which hardens in a few minutes when away from air, has been developed in the chemistry divisions of the General Electric Research Laboratory.

This new substance, called "Anaerobic permafil," is the latest in a series of related compounds, permafils, originally called "Solventless varnishes." It is said to be able to penetrate extremely small cracks before hardening. Thus, a possible application is a tight seal for stopping nearly invisible leaks.

Ordinary varnishes contain some solid resin dissolved in a liquid solvent. They are difficult to use in some applications, *e. g.*, between pieces of metal placed closely together. The solvent nearest the air evaporates, leaving a skin of varnish which seals in the remaining liquid so that it cannot escape. Permafils, on the other hand, are compounds in which the liquid polymerizes and hardens fully without the necessity of any evaporation.

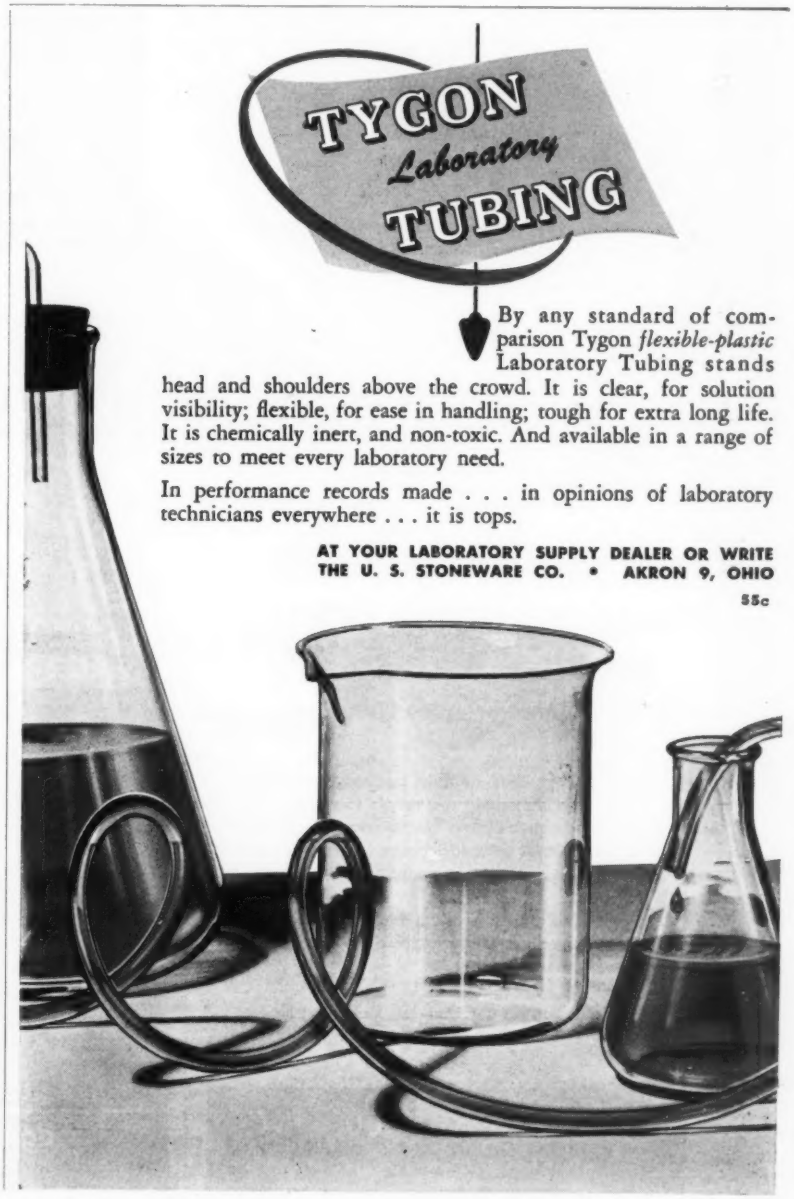
Hydrofluoric Acid Container

A new shelf bottle for hydrofluoric acid, which is said to do away with most of the hazards associated with handling this highly corrosive acid, is the product of J. T. Baker Chemical Co., Phillipsburg, New Jersey.

Made entirely of inert polyethylene, it is constructed with a pouring tube and "drain-back" channel designed to prevent hand injuries due to acid dripping down the outside of the bottle. The construction of this pouring tube also permits drop-by-drop or slow-trickle dispensing in an even, measured flow.

Manometer Bulletin

Scientific Glass Apparatus Co. Inc., Bloomfield, New Jersey, has just issued a new four-page bulletin (Z-251) on their



By any standard of comparison Tygon *flexible-plastic* Laboratory Tubing stands head and shoulders above the crowd. It is clear, for solution visibility; flexible, for ease in handling; tough for extra long life. It is chemically inert, and non-toxic. And available in a range of sizes to meet every laboratory need.

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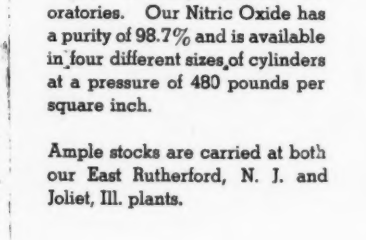

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improved Zimmerli Gauge, a patented manometer for precise vacuum or differential pressure readings which now features two side outlets instead of one.

The bulletin illustrates and describes two models—the "Precision" which has a range of 0 to 100 mm. in 0.1 mm., and the "Utility" with a range of 0 to 100 mm. in 1.0 mm. Five diagrams are pictured, along with easy-to-follow instructions on how to fill and operate the gauge.

According to the manufacturer, the Zimmerli Gauge eliminates the necessity of boiling the mercury in order to remove air. Another claimed feature is the special-size indicating and reference limbs.

Copies of Bulletin Z-251 are available from Scientific Glass Apparatus Co. Inc., 120 Lakewood Terrace, Bloomfield, N. J.

New Chemical Catalog

A new catalog, "Apparatus, Chemicals and Reagents for Colorimetric and Spectrophotometric Chemistry," has just been published by Standard Scientific Supply Corp., 34 West 4th Street, New York 12, N. Y.

The catalog contains 168 pages divided into eight sections. Section I is a complete alphabetical listing of reagents for colorimetric and spectrophotometric chemistry. Section II is made up of an alphabetical listing of chemicals as used in tests outlined in *Manual of Standardized Procedures for Spectrophotometric Chemistry* by Harold J. Fister. Section III lists reagents according to the procedures in Fister's *Manual*. Section IV is a listing of apparatus for use with clinical methods outlined in Fister's *Manual*. Section V is devoted to calibrating standards and reference buffers. Section VI covers reagents and staining solutions; Section VII, biological dyes and Section VIII, culture media.

Copies of this catalog are available free if requested on your official letterhead.

Outline of Chemical History

An unusual outline of the history of chemistry, which is expected to have permanent value for practicing chemists, students, and teachers, can be obtained from the Mallinckrodt Chemical Works, St. Louis 7, Missouri.

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The entries are arranged chronologically, with interconnecting lines to indicate relationships between men, theories, laws, and discoveries. The chart also includes an index of names, with birth and death dates.

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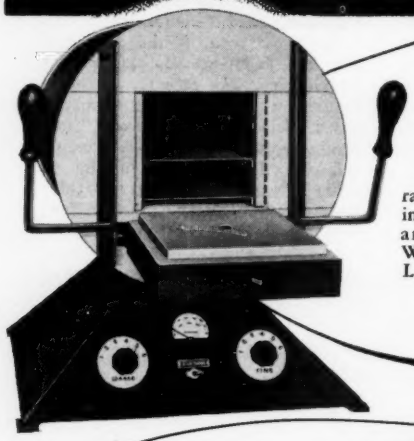

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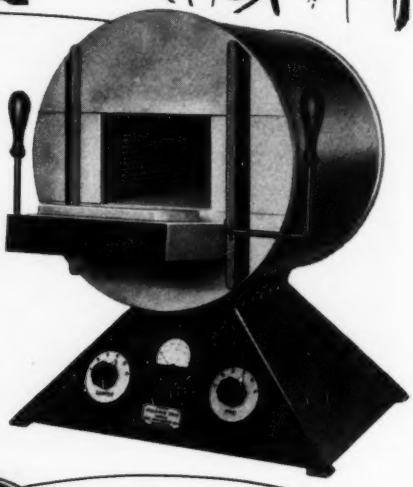

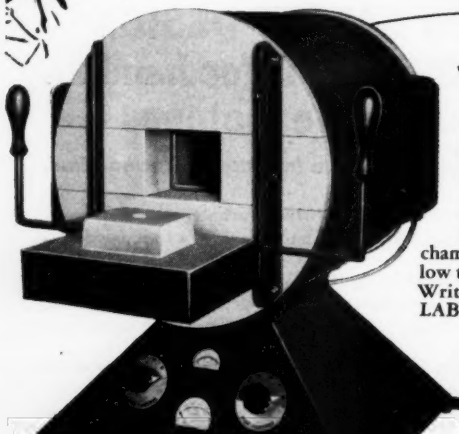

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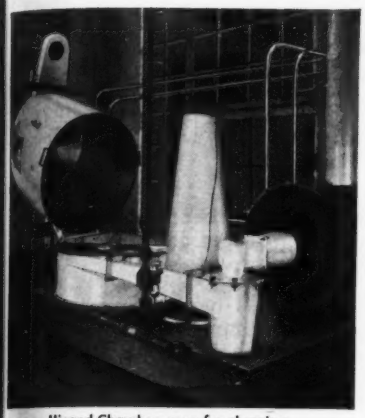

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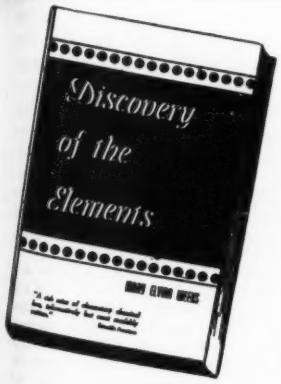

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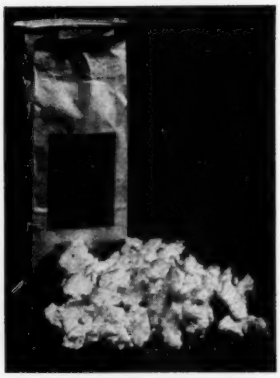

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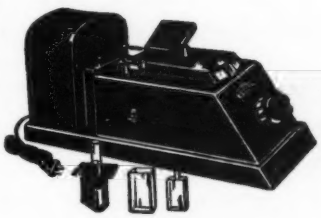

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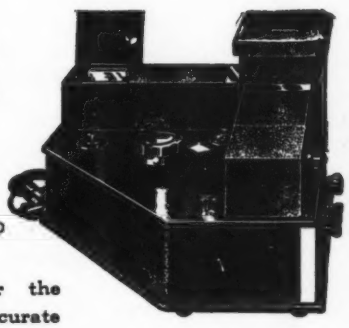

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(1) Ind. Eng. Chem. 25-653 (June, 1933)
(2) Ind. Eng. Chem. 25-1112 (Oct., 1933)
(3) National Bureau of Standards Journal of Research 12-241 (Feb. 1934, R.P. No. 649)

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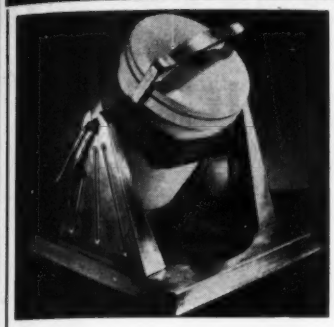

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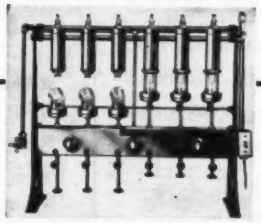

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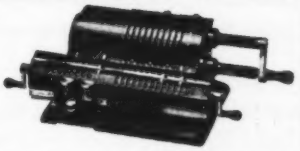

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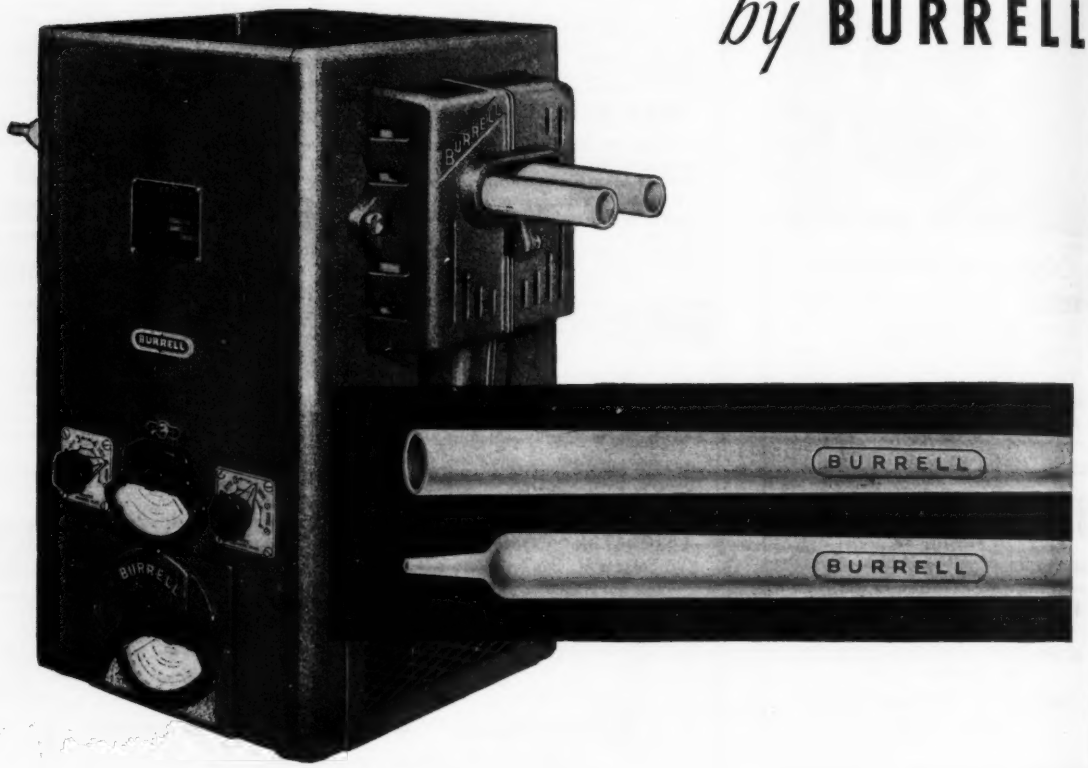

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